



BTM Consult aps

I. C. Christensens Allé 1

DK-6950 Ringkøbing, Denmark

Phone: +45 97 32 52 99, Fax +45 97 32 55 93

e-mail: btmwind@post4.tele.dk

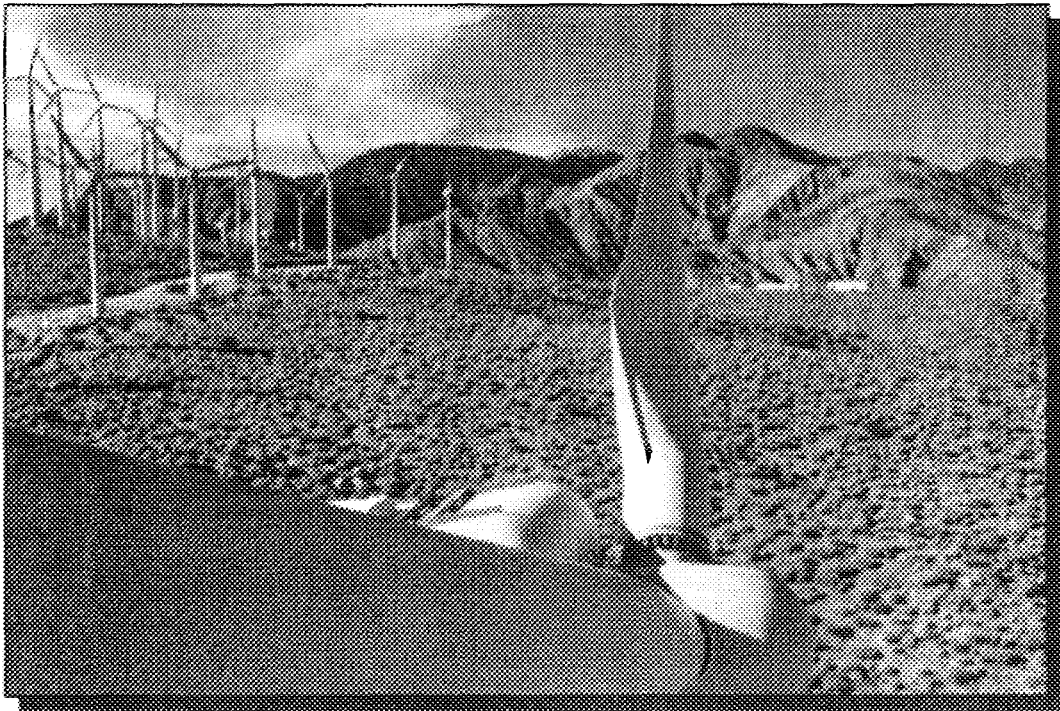
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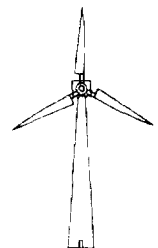
International Wind Energy Development



World Market Update

1996

Forecast 1997-2001



VOL

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Contents

Tables	ii
Figures	iii
Preface	iv
1. Introduction	1
1.1 Methodology	1
1.2 Sources	1
1.3 Major events in the wind industry	2
2. Market development 1996 - demand side	4
2.1 Current product trends in established markets	7
2.2 Emerging new markets in 1996/97	9
2.3 Overall market growth rate	10
2.4 Significant projects in 1996	12
3. Supply side of the market in 1996	14
3.1 The top 10 largest manufacturers	14
3.2 Export share of sales	15
3.3 Nationality of the largest manufacturers	17
3.4 Trends in the competitive market	19
4. Market prognosis and forecasts	20
4.1 Prognosis for market development until 2001	22
4.2 Manufacturers capability versus market demands	25
4.3 Expected development until the year 2005	26
5. Nature of different market segments and drivers	29
5.1 Environmental & Energy driven markets	29
5.2 Market segments characterized by size, etc.	33
Appendices	35
A: Installed capacity in Denmark and the USA	36
B: Installed capacity in Germany and the UK	37
C: Installed capacity in India and Spain	38
D: Installed capacity in Sweden and the Netherlands	39
E: Manufacturers market share in 7 countries during 1996	40
F: Profile of wind turbine manufacturers	44
G: Abbreviations and technical units	47
H: Comments and changes	48
BTM Consult ApS company profile	49

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Tables

Table 2-1: World market 1991-1996	4
Table 2-2: Installed capacity in 1995 and 1996	5
Table 2-3: Average size wind turbine installed each year	7
Table 2-4: Average size wind turbine of accumulated installation	8
Table 2-5: The 10 largest markets in 1996 (installed MW)	11
Table 2-6: The 10 largest markets by the end of 1996 (accu. MW)	11
Table 2-7: Growth rate of the accu. capacity in 1996 and a 3 years average	12
Table 2-8: Installed off-shore projects in the world	12
Table 2-9: Ten selected commercial and precommercial MW class WTG	13
Table 3-1: Market share in 1996 and accumulated share	14
Table 3-2: Market share in 1994, 1995 and 1996	15
Table 3-3: Sales to domestic market and export share in 1996	16
Table 3-4: Average export share for the past 3 years	16
Table 3-5: Added market share for companies from the same country	17
Table 4-1: Prognosis for wind power development 1997-2001	23
Table 5-1: Current and developing markets for wind energy - Market segments	30
Table 5-2: Market Segments and Customers	31
Table 5-3: Segment distribution of installed capacity in 1994-1996	33
Table 5-4: Likely distribution of market segments in the year 2001	34

Figures

Figure 2-1: Annual global wind energy development between 1983-1996	4
Figure 2-2: Total installed wind power capacity by the end of 1990 and 1996	7
Figure 2-3: Different concepts used in 1995 and 1996	9
Figure 3-1: Export and sales to domestic markets 1995 & 1996	17
Figure 3-2: Home country for the 10 largest manufacturers in 1996 and their market shares ..	18
Figure 4-1: Prognosis for the years 1997-2000	24
Figure 4-2: Accu. installed capacity by the end of 1996 and prognosis by 2001	24
Figure 4-3: Expected world market in US\$	25
Figure 4-4: Actual 1990-1996 - Prognosis 1997-2000 - Estimate 2001-2005	27
Figure 4-5: Prognosis for accu. installed capacity by year 2001 and estimate by 2005	27
Figure 4-6: Accumulated wind power development until the year 2005	28
Figure 5-1: Status 1996 and prognosis 1997-2001 divided between market drivers	32
Figure AP-1: Installed capacity in Denmark 1980-1996	36
Figure AP-2: Installed capacity in the USA 1981-1996	36
Figure AP-3: Installed capacity in Germany 1987-1996	37
Figure AP-4: Installed capacity in the UK 1990-1996	37
Figure AP-5: Installed capacity in India 1989-1996	38
Figure AP-6: Installed capacity in Spain 1991-1996	38
Figure AP-7: Installed capacity in Sweden 1990-1996	39
Figure AP-8: Installed capacity in the Netherlands 1990-1996	39
Figure AP-9: Manufacturers market share in Denmark 1996	40
Figure AP-10: Manufacturers market share in Germany 1996	40
Figure AP-11: Manufacturers market share in the Netherlands 1996	41
Figure AP-12: Manufacturers market share in Spain 1996	41
Figure AP-13: Manufacturers market share in Sweden 1996	42
Figure AP-14: Manufacturers market share in the UK 1996	42
Figure AP-15: Manufacturers market share in China 1996	43
Figure AP-16: Manufacturers accu. market share in India until the end of 1996	43

Preface

BTM Consult ApS issued the first version of the report 'International Wind Energy Development' in December of 1995. This report turned out to be a succes which is one of more reasons why we have decided to present this new updated version.

BTM Consult ApS took the initiative in 1995 to conduct a world market research of wind energy development, due to the fact that no similar research had been carried out for a long period of time, meanwhile the market situation has changed rapidly.

In the past 12-14 months, since the first issue, many unexpected changes has been experienced in some of the largest markets for wind energy development. These new conditions have especially effected our prognosis until the year 2000.

The purpose of this research has been to describe and analyze current international wind energy development and new trends until the year 2001.

Acknowledgment

We would like to thank all the people who have helped us with information to update our market data from all over the world. Without their help it would have been most difficult to collect the necessary information. A special thanks goes to all the wind turbine manufacturers who has supplied us with their reference lists for sales during 1996.

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1. Introduction

It is the intention that this report 'International Wind Power Development - Market Update 1996' will be published and updated every year in March. The latest issue was published in December of 1995.

1.1 Methodology

Market data for demand side does normally, where it has been possible, only include installed wind turbines which has been connected to the grid during 1996. Supply side data is based on collected information (reference lists) from the 12-15 largest wind turbine manufacturers in the world. Due to these circumstances there are some conflicts between demand side and supply side data.

Another important factor is that all wind turbine manufacturers do not use the same methodology when they are making their reference lists. Some manufacturers only include installed and operating wind turbines, while others include all units shipped from the factory. This is another conflict that might cause some differences in the data.

Lately another new issue has been added to the list of uncertain factors, which is: is a Nordex Balcke-Dürr wind turbine Danish or German ? And is a Gamesa Eólica wind turbine Danish or Spanish ?, etc. This report consider these WTG's as of Danish origin although the majority of shares in Gamesa Eólica is owned by a Spanish company and not by Vestas. BTM-C has so far chosen to categorize according to where the main facilities are located¹, which in the above cases are in Denmark. One exception is NEPC-Micon which we call Indian made wind turbines. This issue might cause some minor problems if data from this report is compared to information from other reports.

To minimize annual variations, this report includes the last 3 years data for the largest markets and wind turbine manufacturers. The prognosis includes data for the next 5 years until the year 2001, and an estimate has also been included for development until the year 2005.

1.2 Sources

Market data is collected from sources world wide. Important sources have been wind power magazines such as Windpower Monthly, Wind Direction, Wind Energie Aktuel, Windkraft Journal, Wind Energy Weekly, DEWI, SERO Journalen, etc. Most information has been doubled checked via more than one source. Another important source is the statistic data from The Danish Wind Turbine Manufacturers Association (Vind-Note). BTM Consult has besides these sources received information from our worldwide network of consultants, keypersons, etc. in the energy sector.

¹ Although these companies might be owned by foreign capital.

1.3 Major events in the wind industry

Company information

- Kenetech Windpower who has been among the 3 largest wind turbine manufacturers in the world since the early 1980s filed for chapter 11 in May of 1996. The largest part of their assets has since then been sold to other companies, which includes Power Sales Contracts, Operation & Maintenance of wind farms, land rights, and their patented variable² speed concept, etc.
- The German company Balke-Dürr GmbH bought 51% of the stocks in Nordex A/S. Balke-Dürr is part of the large Deutsche Babcock Group which consists of 200 different companies and some 36,000 employees. Balke-Dürr is mainly active in development of technology for power plants and they had a turnover of around 6.5 billion DKK in 1995.
- Zond was bought by Enron Corporation in January of 1997. Zond will hereby become a subsidiary of Enron Renewable Energy Corp. Enron is mainly involved in the natural gas business all over the world but is also involved in solar energy (PV) in the Amoco/Enron Solar partnership. Enron operates the largest natural gas transmission system in America (2nd in the world) and is also the largest purchaser and marketer of natural gas and non-regulated electricity producer in North America. Enron's total assets are approx. USD 15 billion³.
- The Danish company Schouw & Co increased their numbers of shares in Micon from 54.9% to 71.9%.
- Kenetech filed a lawsuit against Enercon in the beginning of 1995 based on allegations related to patent infringement of their variable speed concept. A court decision was made in the fall of 1996 which could ban Enercon from the US market for the next 15 years.

Market information

- The debate in the German Bundestag on the 30th of January 1997, on the topic of the rate of payment for electricity did not, so far, completely clear the air on the rate. The "Verfassungsgesicht" has not made the verdict yet. The first 1.5 MW WTG's were erected in the end of 1995/96 and the first wind farm with MW class WTG's seems to be a reality in 1997 by 12 Nordtank 1.5 MW WTG's.
- The market in India almost disappeared in 1996 which came as a big surprise for many in the wind industry (see more in chapter 2.1). Several manufacturers and subsuppliers had just settled and established local production facilities during 1995 which made it even worse when the market suddenly dropped. In confidence to a continuity in the market place several

² Trace Technologies Inc. (TTI) has purchased the variable speed concept from Kenetech, and the concept is now used by Zond Systems Inc. who also is a financial backer of TTI.

³ Official News Release from Enron of January 6. 1997 and information from the Internet.

manufacturers had built stocks of WTG, kits, spare parts, etc. to be delivered in the forthcoming season. Furthermore, the credit willingness was also reflected by the trust to a continuing market and the sudden drop in the market became hard on everybody. One particular problem was that most of the WTG's to the Indian market was between 2-400 kW which is too small and difficult to sell elsewhere such as in Europe. The sudden drop in the Indian market is in many ways similar to the California market in 1985/86 however the world market has grown so much bigger in diversity that most of the players in the Indian market have been able to cope with a drop, due to better financial backup, etc.

Project information

- A new off-shore wind farm was installed in the Netherlands by Nordtank. This off-shore wind farm consists of 19 units (see chapter 2-4) and is the largest so far. A couple of off-shore projects are already planned for 1997 but large scale off-shore wind power development will most likely not begin before the end of this century, when the large scale 1.5 MW wind turbines have been well tested on land. The Danish government estimate that some 4,000 MW of off-shore wind power will have been installed by the year 2030. The Danish Minister of Environment & Energy, announced in March 1996 that a new committee with members from the Danish Energy Agency and the Danish utilities should have a plan prepared for future off-shore wind energy development by the 1st of July 1997.
- New MW machines were also installed during 1996 (see chapter 2.4) which includes a 1.5 MW model from Tacke and a 1 MW machine from Bonus and Micon.
- Lagerwey (NL) installed a new 750 kW multipoled gearless machine with permanent magnet excitation and 45 meter rotor diameter.
- Zond installed the first large scale project on the Vermont (USA) which consisted of 11 units of the Z-40 WTG (6 MW). The first prototype of the new Z-46 (750 kW) pitch regulated variable speed machine was also installed during 1996 in Tehachapi.
- Seven new Enercon E-40 wind turbines with a total capacity of 3.5 MW were connected to the grid in New Zealand during 1996.
- Bonus installed the largest wind farm in Europe. This wind farm is located near Carno in Wales and consists of 56 units (600 kW) with a total capacity of 33.6 MW.

Other information

- 1996 was a year with only little wind compared to a normal year in Europe. The energy contents in Denmark and Germany was only 80-90% of a normal year.
- The current negotiations under IPCC (Intergovernmental Panel on Climate Change) may end up with mutual commitments to CO₂ reduction targets. The 3rd Conference of Parties takes place in Japan in December of 1997.

2. Market development 1996 - demand side

Global wind power development experienced a small stagnation of annual growth in 1996 after many years of high growth rates, as it can be seen below. It was not until 1993 that the market reached a point higher than its earlier peak of 420 MW in 1985. There was one big difference, more than 95% of the total capacity in 1985 were installed in one market whereas only 90% of the installed capacity in 1993 were divided between 8 different markets.

Figure 2-1 shows annual development of new installed wind power capacity since 1983. The Danish wind turbine manufacturers have had a large market share during most of this period of time. 1996 was a slower year for many manufacturers than 1995, although about the same amount of MW was installed in both years. A main reason is that many of the wind turbines which were shipped from the factories during the end of 1995, were not installed and grid connected until 1996. This issue will be further described in chapter 3.

Table 2-1: World market 1991-1996

Year :	Installed MW	Increase %	USD mill.
1991	240		240
1992	338	+ 41 %	338
1993	480	+ 42 %	480
1994	730	+ 52 %	730
1995	1290	+ 77 %	1290
1996	1292	+ 0.2 %	1292

BTM Consult ApS - December 1996

1 MW installed capacity = approx. USD 1 mill.

Figure 2-1: Annual global wind energy development between 1983-1996

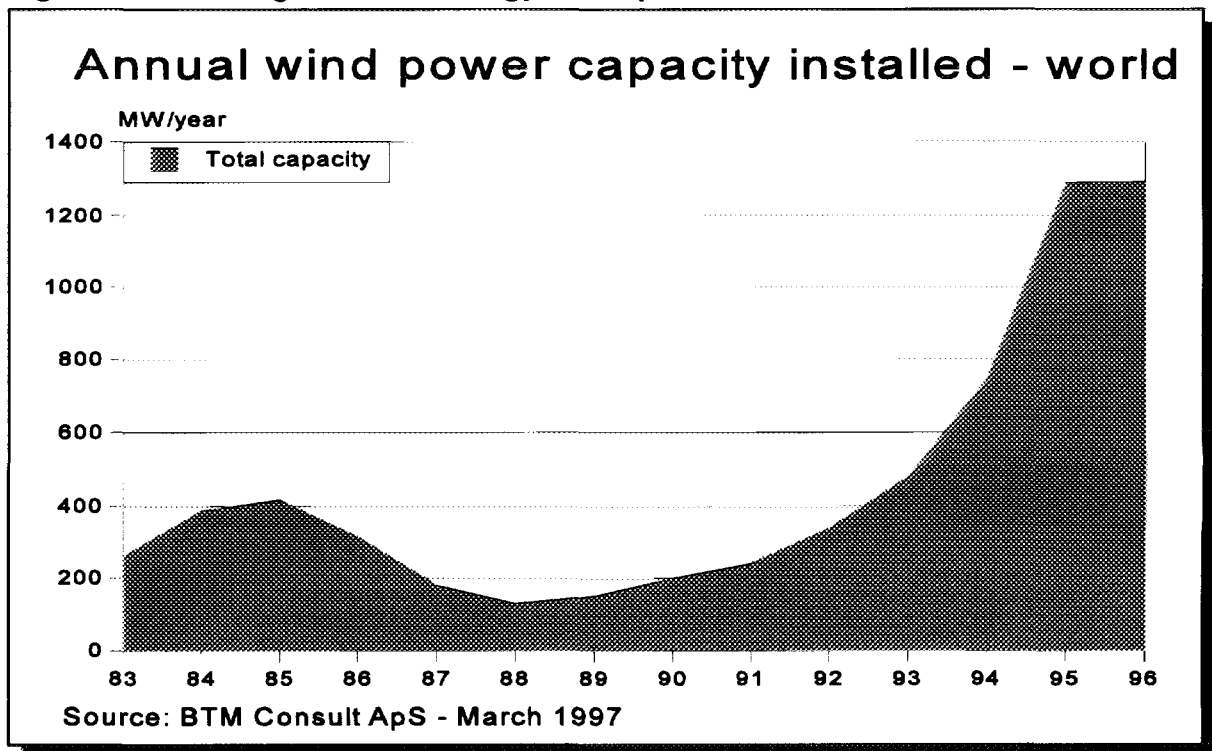


Table 2-2 on the following page shows the exact numbers of new installed MW wind power capacity during 1995 and 1996 divided among countries and regions.

Table 2-2: Installed capacity in 1995 and 1996

	Installed MW 1995	Accu. MW 1995	Installed MW 1996	Accu. MW 1996
USA	53	1591	12	1596
Canada	1	21	0.16	21.1
Mexico	0	1.6	0	1.6
South & Central America	1.3	10	21.8	31.9
Total America	55	1,624	34	1,651
Denmark	98	637	200	835
Finland	1.5	6.1	1.1	7.2
France	0	3	2.7	5.7
Germany	500	1132	420	1552
Greece	0.5	28	1	29
Italy	10.5	32.5	38	70.5
Rep. Ireland	0	7	3.6	10.6
Netherlands	95	249	50	299
Portugal	0	8.5	10.65	19.1
Spain	58	133	116	249
Sweden	29	69	34	103
UK	40	200	73	273
Other European countries: Belgium / Czech Rep. / Slovak Rep. / Norway / Austria / Switzerland / East European countries and others.	3.5	26.1	17.0	43.1
Total Europe	836	2,531	967	3,496
P.R. China	14.5	44	35	79
India	375	576	244	820
Rest of Asia: Korea / Japan / Malaysia /Indonesia / Thailand/ Vietnam etc.	4.1	10.2	2.7	12.9
Total Asia	394	630	282	912
Australia & New Zealand	0	2.9	3.5	6.4
Pacific Islands	0	0.3	2.7	3
North Africa: Egypt, Etiopia, Libya, Tunis, Algeria, Cap Verde, Morocco.	0.2	8.6	0.2	8.8
Middle East: Jordan/ Syria/ Israel /Saudi Arabia/Iran /Iraq. (excl. Egypt)	0	8.0	1.9	9.9
Former Soviet Union: FSU - countries	5.1	16.7	1	17.7
Total other continents and areas	5.3	36	9	46
Total MW installed capacity	1,290		1,292	
Accu. MW installed in the world		4,821		6,104

BTM Consult ApS - March 1997

Notice: The accumulated installed capacity for the end of 1996 is not always equal to the 1995 data plus installed capacity during 1996. Adjustments have been made by considering the amount of dismantled capacity. The numbers for the USA has especially been effected by this adjustment.

Comments to table 2-2:**EUROPE**

Denmark: 221 MW were sold in 1996 according to statistics from the Association of Danish Wind Turbine Manufacturers, but only around 200 MW were installed and grid connected.

Spain: Information from the Spanish market varies from source to source and the data is highly influenced by individual judgement whether a single project is installed and grid connected before the end of the year or not. The manufacturers market shares are therefore also influenced by these judgements.

ASIA

India: The installed capacity in India has increased by some 244 MW during 1996, although only few wind turbines were exported (shipped) to India. This is because most of these machines were sent to India in 1995, but not installed and connected to the grid until 1996. *It is still a little doubtful whether 820 MW are actually installed and operating at present time but this is the official number issued by MNES (Ministry of Non-Conventional Energy Sources) in India. We have only been able to trace around 700 MW according to references from the 15 largest wind turbine manufacturers in the world.* Some sources have indicated that the 820 MW does also include approved projects which has not yet been installed.

The current trend for wind power development in India is still not as high as expected. Although, activities has increased in the past few months. The unstable investment climate started in the beginning of 1996 before the election based on fear for an uncertain future. The outcome of the election has been a new minority government which consists of 13 different parties. The period since the election has mainly been an adjustment period for the new government. It is not only the wind industry that has been affected by this economic growth stagnation, but most industries have slowed down considerably due to the unstable investment climate and low earnings⁴. Other factors have been an decrease of foreign investments and high rates of interest (18-19%).

The payment for electricity is presently INR 2.25/kWh and the wind turbine owner has to pay INR 0.1 per unit reactive power drawn from the grid. A set of new guidelines were issued by MNES which covers aspects such as type approval, quality certification, and power quality, etc. for new wind projects installed in India. The political will to use renewable energy and the overall need for electricity is still present in India which indicates that the market most likely will return soon.

China: Around 35 MW were shipped to China during 1996. It is still a little uncertain exactly how many of these that were installed and grid connected.

REST OF THE WORLD

Data for the Middle East and North Africa has been adjusted since 1995 due to new findings.

⁴ Potential investors such as large companies has not been able to use the tax deductible which they get by investing in wind energy, due to low earnings.

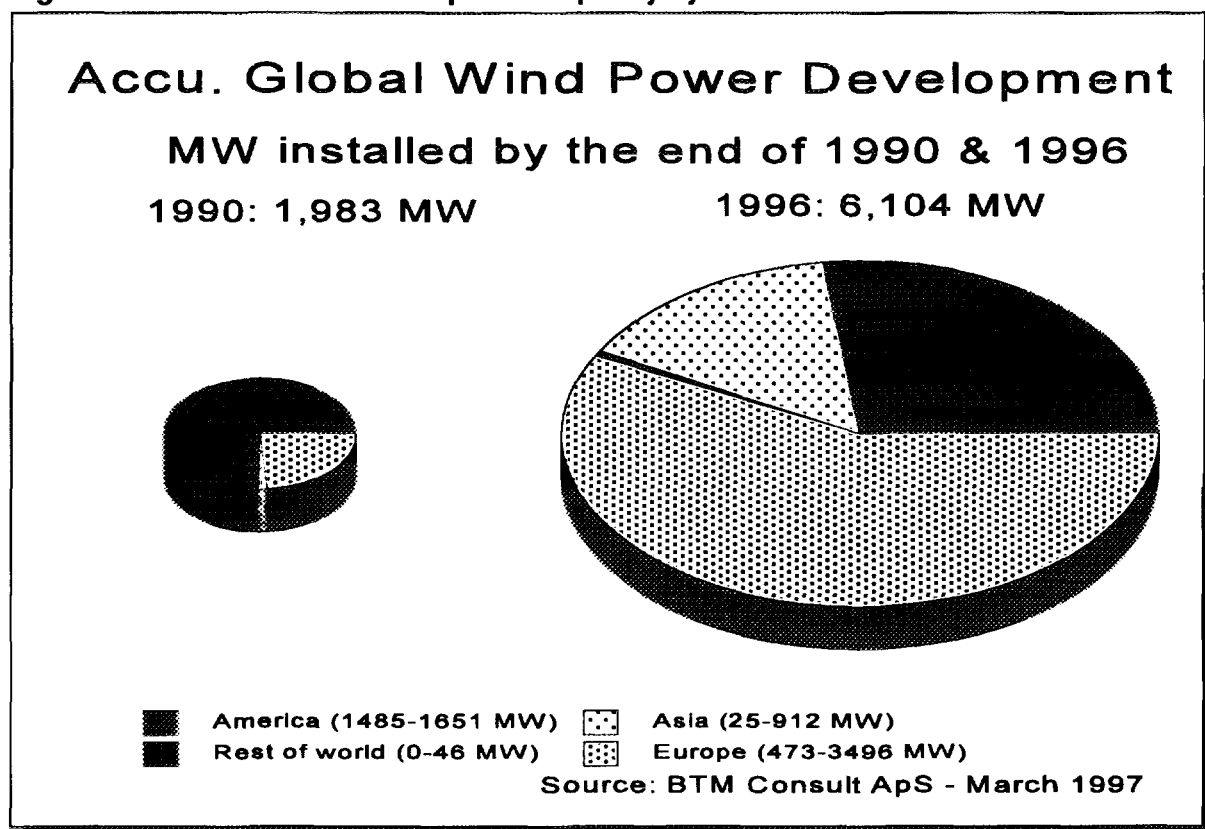
Figure 2-2: Total installed wind power capacity by the end of 1990 and 1996

Figure 2-2 shows the dispersal of the total installed wind power capacity in the world between regions/countries by the end of 1990 compared to the end of 1996. The American share of the pie is still decreasing rapidly as Europe and Asia is taking over the market place.

2.1 Current product trends in established markets

The average new installed WTG size has increased from around 250 kW to more than 500 kW in a period of 5-6 years (1990-1996), and this trend for larger machines is expected to continue in 1997 due to the introduction of the MW size WTG which will most likely continue the trend for several years ahead.

Table 2-3: Average size wind turbine installed each year

Year	Denmark	Germany	Sweden	UK	USA
1992	215 kW	185 kW	212 kW	361 kW	204 kW
1993	248 kW	254 kW	247 kW	320 kW	137 kW
1994	364 kW	371 kW	413 kW	469 kW	336 kW
1995	493 kW	473 kW	448 kW	534 kW	327 kW
1996	531 kW	530 kW	459 kW	562 kW	511 kW

BTM Consult ApS - March 1997

The accumulated average is also increasing and it shows that countries such as Denmark and the USA have been affected by development in the early 1980s with many small WTG's. There were almost the same numbers of installed units in Denmark and Germany by the end of 1995 but the capacity in Germany was almost the double.

Table 2-4: Average size wind turbine of accumulated installation

Year	Denmark	Germany	Sweden	UK	USA
1992	119 kW	117 kW	221 kW	299 kW	105 kW
1993	123 kW	182 kW	227 kW	312 kW	105 kW
1994	131 kW	264 kW	257 kW	353 kW	112 kW
1995	148 kW	310 kW	311 kW	360 kW	118 kW
1996	181 kW	358 kW	345 kW	398 kW	115 kW

BTM Consult ApS - March 1997

Technical concepts

New and more advanced concepts are still being introduced to the market. Vestas introduced OptiSlip in 1995, and Wind World is presently introducing their Optimal Speed Control system. Both of these systems are semi variable speed control systems. Tacke is using full variable speed control on their new 1.5 MW machine as well as pitch regulation, compared to their normal concept which has been stall regulated constant speed WTG.

Semi- and full variable speed control systems provides several benefits. Among these are e.g. a smooth interconnection to the grid with only little disturbances and the possibility to adjust $\cos \phi^5$ which has become a key factor for many utilities in Europe. This is also an important factor on a weak grid. The system also reduces the need for reactive power which an asynchronous generator needs from the grid to work. Another important issue is noise emission from the blades which can be reduced by reducing the rpm. of the rotor. This will normally also improve the blade efficiency at low wind speeds. Noise problems are normally only an issue at low wind speeds, where the background noise from the wind is at a minimum.

In the middle of 1996 Lagerwey introduced a new 750 kW multipoled permanent magnet WTG with variable speed. They are the second manufacturer in the market with such a model⁶. Available data shows that the costs for the multipoled PMG generator is still too high but the market price for magnets have been decreasing over the past years. This decrease is expected to continue.

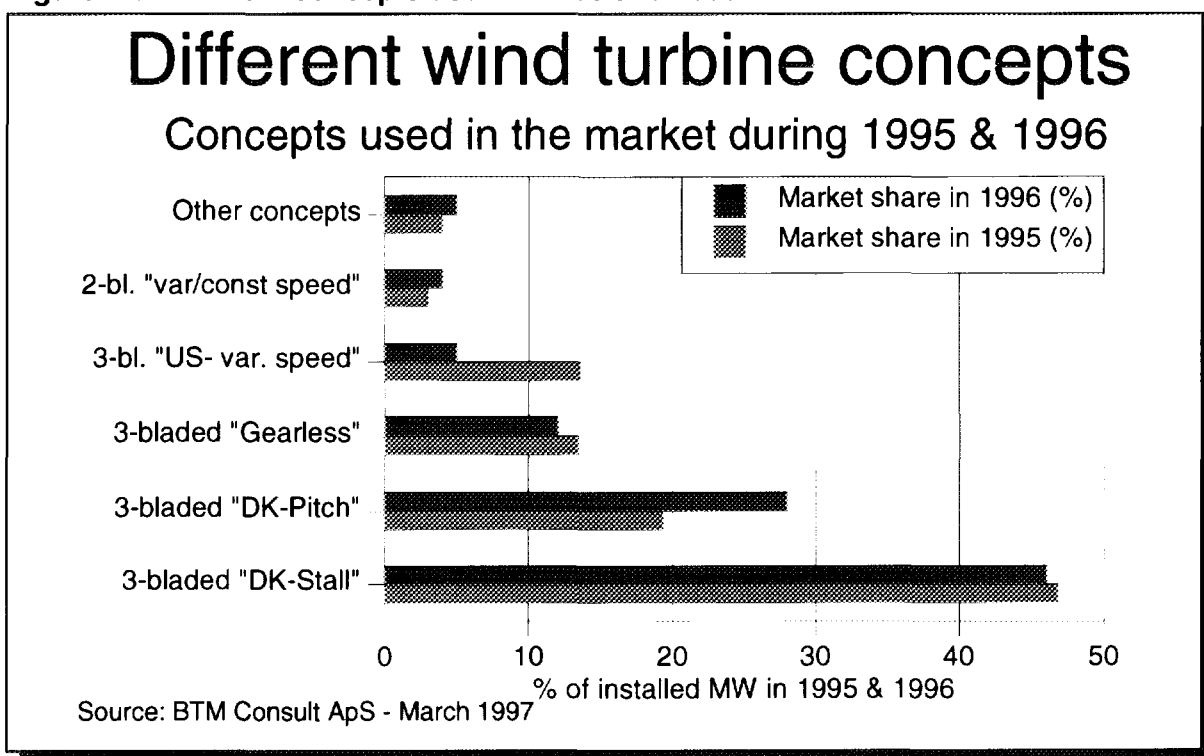
Figure 2-3 shows the distribution of sales between different concepts in the market during 1995 and 1996. The simple stall regulated concept is still the most common. Although, many models

⁵ ϕ is the phase angle between the current and the voltage output from the generator and $\cos \phi$ has to be close to 1. The true and the apparent power output is equal to each other when $\cos \phi$ is equal to 1.

⁶ Enercon is the other manufacturer, but their generator does not use permanent magnets

today are pitch regulated. Constant speed WTG's are still much more common than variable speed but new semi variable speed concepts have been introduced.

Figure 2-3: Different concepts used in 1995 and 1996



2.2 Emerging new markets in 1996/97

This section deals with emerging new markets during 1996/97 and established markets with significant growth during this period of time.

Spain has been among the fastest growing new markets in the last couple of years due to an attractive political climate and attractive payment rates, which has made a rapid development possible. Further expansion in the 200 MW range is expected for the next year.

The development in **Denmark** increased rapidly in 1996 with some 200 MW of new capacity in the year. This should have been to the joy of everybody, but the Danish Ministry of Energy effectually brought this development to a stop. The sudden market expansion came from what, by the Danish politicians was considered as a hole in the law. Basically, you could live in one place and buy a WTG in another part of the country. It is mandatory that you can only own a WTG on a piece of land which you own and where you live.

One Project of 20 MW was initiated in **Costa Rica** during 1996. Further projects are under preparation - but there is still not an official national goal of Wind Energy penetration (percentagewise) in the Costa Rican grid. The market is limited.

New Zealand is blessed with an excellent wind regime and some development by Enercon and Vestas Wind Systems A/S has taken place as a first initiative. However a political goal still remains to be published. Enercon installed 3.5 MW in 1996 which was added to the existing 225 kW of wind power capacity.

Some 11 MW were installed in **Austria** during 1996 by several different wind turbine manufacturers. Low payment of electricity rates seems to be a limiting factor along with the lack of political will and a goal of setting numbers on the installation rate in the nearest years. Efforts are being made in Austria to get similar payment rate as in Germany, which could result in a bigger market than expected.

Wind development in **Italy** finally took some positive steps in 1996. Some 38 MW were installed. Mainly thanks to some private interest in the development. Total installation in Italy is now 70 MW on 193 WTG's.

New plans and political goals

Finally some political goals and numbers came from **Ireland**. The target of at least 410 MW seems however to be a very modest target in a wind rich region like Ireland.

France has finally taken move towards a rate of installation. There is now an official French goal over the next nine years to buy electricity from wind turbines in the range of 250 to 500 MW. This is still a modest goal in a vast country like France which is blessed with excellent wind regimes. Future development in France is different from most other countries since it is expected to be controlled by the national utility (EdF).

The **Moroccan** development of 50 MW with VESTAS wind turbines in cooperation with Compagnie Eolienne du Detroit (France) seems near to materialize by the end of 1997.

Denmark released a new energy plan in 1996 called ENERGY 21 which confirm previous goals of 10% wind power electricity by the year 2005. This new plan does also include, a section which estimates some 4,000 MW of off-shore wind power by the year 2030.

2.3 Overall market growth rate

Market development in the 10 largest markets for the past 3 years are shown based on annual installations in table 2-5 and cumulative installed capacity in table 2-6. The ten markets represented 94.7% of the world market in 1996, which was a little less than the year before. This indicates a broader dispersion in the market place.

Table 2-5: The 10 largest markets in 1996 (installed MW)

Country	1994	1995	1996
Germany	306	500	420
India	141	375	244
Denmark	52	98	200
Spain	23	58	116
UK	30	40	73
Netherlands	22	95	50
Italy	7	11	38
P.R. China	18	14	35
Sweden	10	29	34
USA	90	53	12 ⁷
Total	699	1,273	1,222
Percent of world	95.8%	98.7%	94.7%

Source: BTM Consult ApS - March 1997

Table 2-6: The 10 largest markets by the end of 1996 (accu. MW)

Country	1994	1995	1996
USA	1,662	1,591	1,596
Germany	632	1,132	1,552
Denmark	539	637	835
India	201	576	820
Netherlands	154	249	299
UK	160	200	273
Spain	75	133	249
Sweden	40	69	103
P.R. China	29	44	79
Italy	22	33	71
Total	3,514	4,664	5,877
Percent of world	94.1%	96.7%	96.3%

Source: BTM Consult ApS - March 1997

Table 2-7 shows the accumulated growth rate in the 10 largest markets during 1996 and also the average growth rate for the past 3 years in the same countries.

⁷ Costa Rica should actually have been number ten in 1996 with some 20 MW of installed capacity but has not been included due to the following reasons: nothing has been installed before this one large project, not too much is expected in the future, etc.

Table 2-7: Growth rate of the accu. capacity in 1996 and a 3 years average

Country	Accu. installed 1995	Accu. installed 1996	Growth rate 1995-1996 %	Average accu. growth '94-'96 %
USA	1,591	1,596	0.3%	-1.3%
Germany	1,132	1,552	37.1%	34.9%
Denmark	637	835	31.1%	15.7%
India	576	820	42.4%	59.8%
Netherlands	249	299	20.1%	24.8%
UK	200	273	36.5%	19.5%
Spain	133	249	87.2%	49.2%
Sweden	69	103	49.3%	37.1%
P.R. China	44	79	79.5%	39.7%
Italy	33	71	115.2%	47.8%

Source: BTM Consult ApS - March 1997

2.4 Significant projects in 1996

Off-shore

A new off-shore wind farm was installed in the Netherlands by Nordtank. This off-shore wind farm consists of 19 units and is the largest so far. The first off-shore wind turbine was installed in 1990 by Wind World in Sweden. Since then 4 other projects has been installed, two are in Denmark and the other two in Holland. Table 2-8 shows that all together there are 45 wind turbines with a total capacity of 23.57 MW.

Table 2-8: Installed off-shore projects in the world

Location	Units	Made/Size	Capacity MW	Year	Country
Nogersund	1	Wind World 220 kW	0.22	1990	Sweden
Vindeby	11	Bonus 450 kW	4.95	1991	Denmark
Lely (Ijsselmeer)	4	NedWind 40-500 kW	2.0	1994	Netherlands
Tunø	10	Vestas V39-500 kW	5.0	1995	Denmark
Dronten I (Ijsselmeer)	19	Nordtank 600 kW	11.4	1996	Netherlands
Total	45		23.57		

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All of these off-shore projects are installed relatively close to the shoreline, between 1-5 km. The most recent project which is Dronten I in The Netherlands is located just some few meters off a pier. Common for these projects are also that they are intended as pilot or pre-commercial projects. Many aspects has to be covered before large scale development can start, such as e.g. technical durability under these conditions, their impact on birds, fish, etc.

Large scale off-shore wind power development will therefore most likely not begin before the end of this century, when the large scale 1.5 MW wind turbines have been well tested on land. A potential of 8,000 MW has already been identified on just 4 different sites in the surrounding

waters of Denmark. These areas are all located within 20 km off-shore and with shallow water between 5-10 meters. The Danish government estimates that some 4,000 MW of off-shore wind power will have been installed by the year 2030. The Danish Minister of Environment & Energy, announced in March 1996 that a new committee with members from the Danish Energy Agency and the Danish utilities should have a plan prepared for future off-shore wind energy development by the 1st of July 1997.

MW Technology has entered the market

Many new MW wind turbines were introduced to the market in the end of 1995 and during 1996. Table 2-9 shows a list of 10 selected models.

Table 2-9: Ten selected commercial and precommercial MW class WTG

Name	Country	No. of blades	Capacity kW	Rotor (m)	Swept area (m ²)	Stall/pitch const./var speed ¹	Units installed incl. prototype	Prototype (month/year)
AutoFlug A1200	D	2	1200	61	2922	Pitch (C)	1	10/96
Bonus 1 MW	DK	3	1000	54	2290	Active Stall (C)	1	07/96
Enercon E-66/1500	D	3	1500	66	3421	Pitch (V) ²	2	12/95
HSW 1000/57	D	3	1000	57	2552	Pitch (C)	4	12/95
Micon M2300-1000	DK	3	1000	54	2290	Stall (C)	1	06/96
NedWind 53-1000	NL	2	1000	52,6	2173	Active Stall (C)	6	02/94
Nordex N-54	DK	3	1000	54	2290	Stall (C)	23	02/95
Nordtank NTK 1500	DK	3	1500	60	2827	Stall (C)	1	09/95
Tacke TW 1,5	D	3	1500	65	3318	Pitch (V)	1	04/96
Vestas V63-1500	DK	3	1500	63,6	3117	Pitch (O)	1	12/95

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¹: V = Variable Speed - C = Constant Speed - O = OptiSlip (Semi-variable speed - Vestas feature)

²: Multipoled generator (direct drive)

For the most part, manufacturers seem to be sticking conceptually close to their basic design of their smaller machines in the design of their MW plant. According to information provided by manufacturers, MW machines will be delivered in increasing numbers to projects in 1997.

Costa Rica: The first large scale wind farm of 20 MW was installed in Costa Rica by Kenetech

Portugal: Vestas installed 10.6 MW which more than doubled the installed capacity.

New Zealand: Enercon installed the first large scale project in New Zealand which consisted of 7 units of their E-40 model (3.5 MW).

3. Supply side of the market in 1996

The numbers used in this chapter are based on information collected via company reference lists and they might therefore not be exactly the same as the data for demand side, which previously has been described in chapter 1.1. Appendix F gives a short profile of the major wind turbine manufacturers which are described in this chapter.

3.1 The top 10 largest manufacturers

The 10 largest wind turbine manufacturers has for several years consisted of almost the same companies. Although, their positions have varied from year to year. Table 3-1 shows the total sales from the largest manufacturers during 1996 and their accumulated sales over the years. The ranking is based on their accumulated sales by end of 1996. Two particular companies, Kenetech and Mitsubishi, is only on the list due to high sales numbers in previous years.

Table 3-1: Market share in 1996 and accumulated share

	Accu. MW 1995	Installed MW 1996	Share 1996 %	Accu. MW 1996	Share accu. %
VESTAS	996	308	23.9%	1,304	20.6%
KENETECH	686	20	1.6%	706	11.1%
MICON	397	134	10.4%	531	8.4%
ENERCON	355	153	11.9%	508	8.0%
BONUS	347	117	9.1%	464	7.3%
NORDTANK	350	82	6.4%	432	6.8%
TACKE	201	83	6.4%	284	4.5%
NEPC	226	36	2.8%	262	4.1%
MITSUBISHI	200	4	0.3%	204	3.2%
WIND WORLD	154	29	2.3%	183	2.9%
NEDWIND	118	32	2.5%	150	2.4%
WIND MASTER	121	19	1.5%	140	2.2%
NORDEX	97	38	3.0%	135	2.1%
Other manufacturers	937	73	5.6%	1,010	15.9%
Total	5,185	1,128	88%	6,313	100%

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At first it might seem odd that the total market share is only 88% of the installed capacity during 1996, but this will be further described in the following table.

Table 3-2 shows the annual sales from the same companies for the past 3 years and their market share year by year. This shows the stability of the individual companies and their position among the leading companies in the wind industry. Vestas has been at the top for the whole period of time.

A new observation is that 'other manufacturers' are gaining a larger part of the market which has

increased from 2.3% in 1994 to 5.6% of all wind turbines sold in 1996. This is mainly due to many new markets with local manufacturers such as Spain.

Table 3-2: Market share in 1994, 1995 and 1996

	Installed MW 1994	Share 1994 %	Installed MW 1995	Share 1995 %	Installed MW 1996	Share 1996 %
VESTAS	149	20.4%	273	21.2%	308	23.9%
KENETECH	104	14.2%	150	11.6%	20	1.6%
MICON	63	8.6%	117	9.1%	134	10.4%
ENERCON	102	14%	163	12.6%	153	11.9%
BONUS	55	7.5%	88	6.8%	117	9.1%
NORDTANK	61	8.4%	66	5.1%	82	6.4%
TACKE	76	10.4%	110	8.5%	83	6.4%
NEPC	62	8.5%	164	12.7%	36	2.8%
mitsubishi	0.5	0.1%	1.5	0.1%	4	0.3%
WIND WORLD	24	3.3%	83	6.4%	29	2.3%
NEDWIND	23	3.2%	39	3.0%	32	2.5%
WIND MASTER	1	0.1%	23	1.8%	19	1.5%
NORDEX	22	3.0%	55	4.3%	38	3.0%
Other manufacturers	17	2.3%	73	5.6%	73	5.6%
Total	760	104%	1,405	109%	1,128	88%

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Periodic adjustment:

The total sales in 1994 were 760 MW but only 730 MW were installed. This means that 30 MW were sold but not installed before the next year. The same happened in 1995 where some 1,405 MW were sold but only 1,290 MW were installed and grid connected the same year. This means that 115 MW were sold but not installed by the end of 1995. The exact opposite was the case in 1996 where only 1,128 MW were sold but 1,292 MW installed which makes a difference of -164 MW. The total for these 3 years is that 3,293 MW were sold and 3,312 MW were installed. This is a difference of around 0.6%.

3.2 Export share of sales

1996 did not show any considerable changes in the export trends among the leading companies. The Danish companies are still exporting a very large part of their machines although there was a slight decline in 1996⁸ due to an extremely good year in the domestic market. The German companies are still only exporting a small part of their total sale. Table 3-3 shows the export share for the largest wind turbine manufacturers during 1996.

⁸ There was a small increase of MW exported, but the domestic market doubled which resulted in a decline of the export percentage.

Table 3-3: Sales to domestic market and export share in 1996

	Total sale 1996 MW	Domestic 1996 MW	Export 1996 MW	Export share %
VESTAS	308	80	228	74.0%
ENERCON	153	135	18	11.8%
MICON	134	74	60	44.8%
BONUS	117	23	94	80.3%
TACKE	83	74	9	10.8%
NORDTANK	82	14	68	82.9%
NORDEX	38	2	36	94.7%
NEPC	36	36	0	0%
NEDWIND	32	7	25	78.1%
WIND WORLD	29	11	18	62.1%
KENETECH	20	0	20	100%
WIND MASTER	19	14	5	26.3%
MITSUBISHI	4	0	4	100%
Total	1,055	470	585	55.5%

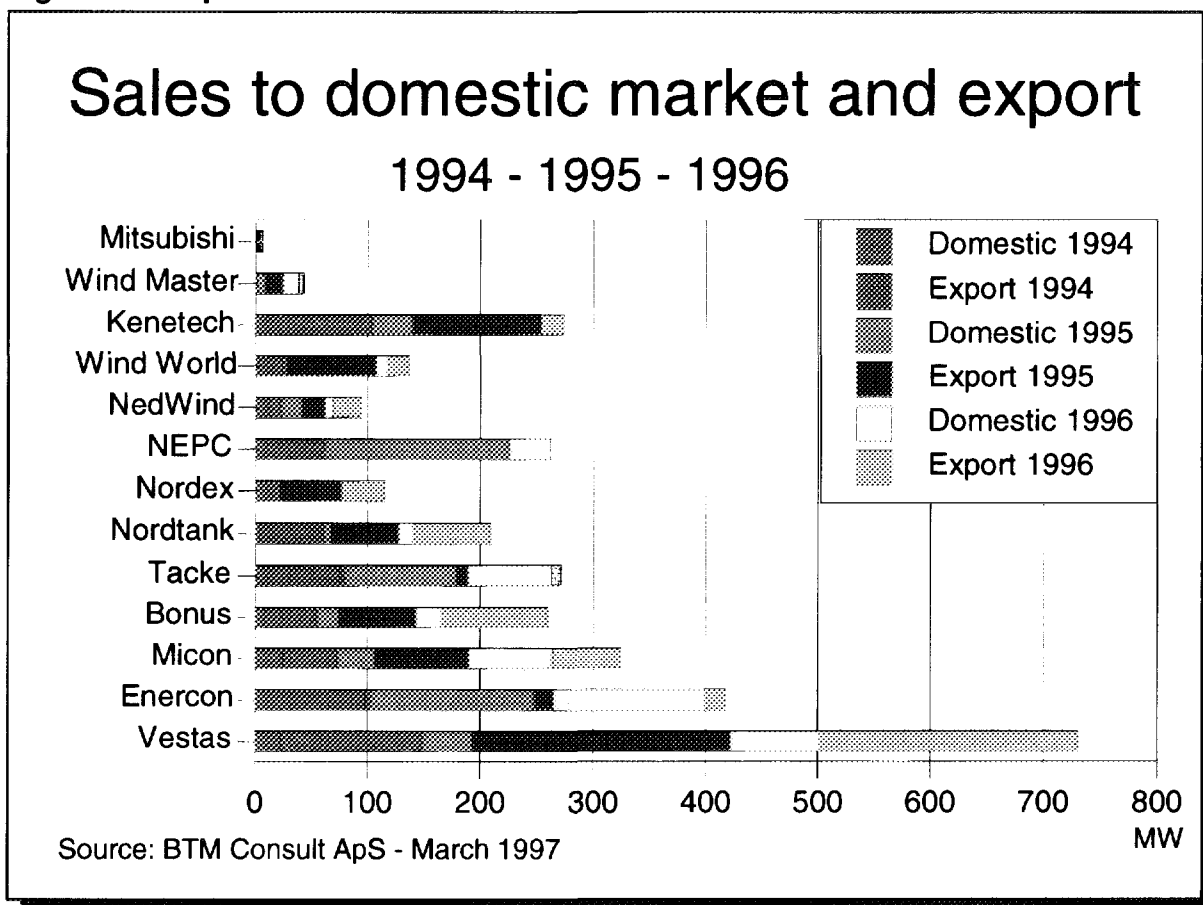
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Table 3-4 shows the total sales for the same companies for the past 3 years and the average export share in this period of time.

Table 3-4: Average export share for the past 3 years

	Total sale 1994 MW	Total sale 1995 MW	Total sale 1996 MW	Sum of 3 years installed MW	Average export share for the past 3 years
VESTAS	149	273	308	730	79.9%
ENERCON	102	163	153	418	9.3%
MICON	63	117	134	314	60.8%
BONUS	55	88	117	260	80.4%
TACKE	79	110	83	272	8.5%
NORDTANK	61	66	82	209	88.5%
NORDEX	22	55	38	115	98.3%
NEPC	62	164	36	262	0%
NEDWIND	23	39	32	94	60.1%
WIND WORLD	24	83	29	136	87.9%
KENETECH	104	150	20	274	52.6%
WIND MASTER	1	23	19	43	49.5%
MITSUBISHI	0.5	2	4	6	66.7%
Total	746	1,333	1,055	3,133	53.9%

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Figure 3-1: Export and sales to domestic markets 1995 & 1996

3.3 Nationality of the largest manufacturers

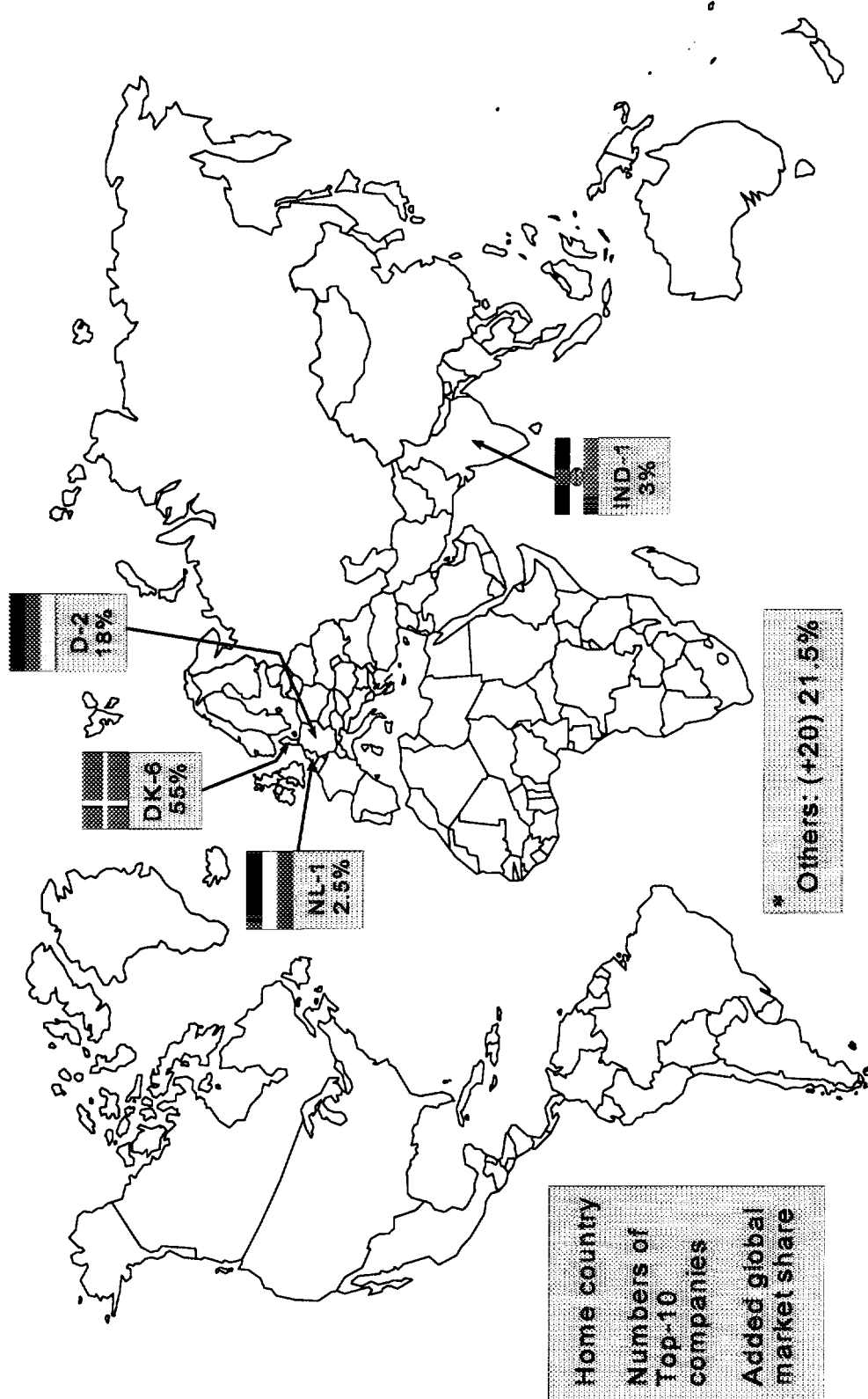
Table 3-5 shows the added market share for all wind turbine manufacturers from the same country. The Danish and Spanish companies have increased their market share while companies from other countries have lost a part of the market. Especially companies from India and the USA have been affected, mainly due to a slow domestic market.

Table 3-5: Added market share for companies from the same country

	1994	1995	1996
Denmark	51%	53%	55%
Germany	23%	22.2%	20.4%
India	8.9%	13.1%	3%
Netherlands	4.4%	5.6%	4.4%
Spain	2.4%	2.7%	3.1%
USA	14.3%	12.4%	2.1%
Total	104%	109%	88%

Source: BTM Consult ApS - March 1997

The global wind industry (The 10 largest - 1996 sales)



*) Other manufacturers does also include smaller companies from the leading countries.

BTM Consult ApS - March 1997

Figure 3-2: Home country for the 10 largest manufacturers in 1996 and their market shares

Figure 3-2 shows what part of the world that the 10 largest wind turbine manufacturers were located in 1996. Furthermore it shows these manufacturers added market share of the global installed wind power capacity. The category "Others" includes companies from all over the world including other companies from Denmark, Germany, India and the Netherlands. The total added market share for all wind turbine manufacturers from the same country is shown in table 3-5. All these numbers are based on a total of 1,292 MW installed wind power capacity during 1996.

3.4 Trends in the competitive market

The WTG's are commercially growing into the MW class. Nearly all major manufacturers can now announce some track record in the 1-1.5 MW class. However, we still have not seen whether these WTG's are commercially viable compared to the 600-750 kW class which has shown good economy so far.

Undoubtedly the MW size WTG's will be needed to go off-shore to bring the cost from off-shore installations down. This is especially due to the relative lower cost for the foundation used by a MW machine compared to a 5-600 kW machine. It will be difficult for manufacturers to compete in the future marketplace without having a MW size WTG in the sales program. This is also the wind turbine size which the utilities will ask for when they are forced to enter the wind power market.

The role of the utilities will most likely increase in the coming years. The new MW wind turbines are of such sizes that it will need very careful planning years ahead of the installation. In case of the private sectors involvement it seems like it will be in the role of pension fund and/or conglomerates outsourcing the task of installations and management to experts in the field.

There will be fierce competition among the manufacturers in spite of a growing market in the coming years. Manufacturers will still be fighting to get the largest share of the market. Even fairly good years with approx. 1,200 MW per year (1995 & 1996) showed that several manufacturers had serious financial problems while other collapsed. Among those were the largest US manufacturer, Kenetech Windpower, who filed chapter 11 in 1996. Economic results from main manufacturers in 1996 are not exactly staggering. This is leaving one to believe that more economic shake out will be seen in the years to come.

4. Market prognosis and forecasts

The market prognosis in this report is based on years of experience with market analysis in the wind power industry which is used to predict future market development. Experience has shown that the yearly estimate for global wind power development is generally rather close to the correct number. The market diversity is today so broad that even though one or two markets fails to live up to the expectations, other markets will fulfil this gap. This also means that one has to look at the full 5 year period to get the most accurate picture of the prognosis, since variations might occur year by year.

The prognosis is based on an analysis of the frame work for renewable energy development in individual countries which among others includes:

- National energy plans and governmental support for renewable energy
- Actual growth in the market until now and present dynamic in the industry
- Wind resources available in the market
- Technological development in terms of commercial available WTG sizes
- Assessment of previous patterns of development and likelihood of replication in new markets

The following comments are supposed to clarify some of the uncertainties attached to the numbers in table 4-1 according to present knowledge about some of the individual markets.

AMERICA

- Annual development in the **USA** is difficult to predict, due to few but large projects. The prognosis is sensitive for the individual year and will be highly affected if just one or two projects are postponed or delayed. Several of these large proposed projects which are located in California, Iowa, Minnesota, Texas, Wyoming and the North Western states were planed to be installed in 1995/96 but have been postponed until 1997/99. The USA has an enormous potential for wind power development if the right conditions are established. The market could therefore be much bigger than estimated if this happens.
- Similar concerns are present in **Canada** as well as the USA
- There has been identified a huge wind resource potential in **Latin America**, especially in countries such as Argentina, Brazil and Chile. One of the main barriers are lack of electrical infrasturcture (high voltage grid) and a low payment for electricity. The first large scale project to be materialized is expected to be a 60 MW wind farm in the northeastern part of Brazil.

EUROPE

- Development in **Denmark** during 1996 was the highest ever, and most recent information indicates that 1997 will most likely be as good. This is mainly due to a loophole found in the regulations in 1995 which was stopped in 1996 but already planned projects have been

allowed to proceed. The majority of installed capacity in 1996 was based on these conditions which will most likely also be the case in 1997. The future for private development in 1998 and ahead is very uncertain and the largest part will most likely be utility owned projects. The Danish utilities have been mandated to installed 200 MW (ELSAM: 120 MW, ELKRAFT: 80 MW) between the beginning of 1996 and the end of 1999. Only a very small part of this has already been installed and previous examples has shown that the utilities often have been delayed 1-3 years to fulfil their requirements.

- The present situation in **Germany** and the uncertainty about future payments for electricity produced by wind power has a high influence of how the market will react. There is still a large potential for wind power development but most of these areas are located inland with a relative low average wind speed. This means that the market could very well decrease even more than expected if the payment is lowered from the present level at 17.2 pf/kWh to the proposed level between 12-14 pf/kWh. On the other hand, the market could also be larger than expected in the prognosis if the current debate is ended soon in favour of wind power.
- The development patterns in **Spain**, mainly shows larger projects which are similar to those experienced in the USA although more steady. Spain has a vast geographical potential for wind power development, and a fairly high fixed payment for electricity⁹. It is still uncertain when the development in Galicia will start to pick up but the conditions are looking very promising and could very likely result in a much bigger market than estimated in the prognosis.
- The current debate in **Sweden** about decommissioning of their nuclear power plants will most likely benefit wind power development as one of the only supplements without increasing CO₂ emission. It is difficult to estimate how soon this will start to take effect and the current situation for 1997 does not look too good. The 30% investment incentive was stopped in 1996 and the payment for electricity is not high enough to establish a big market. The Swedish government is presently working on a new incentive for wind power development. It is still unknown how soon these changes will be ready and the effect they will have on wind power development in Sweden.

ASIA

- Expected development in **India** until the year 2000 is mainly based on the assumption that market development will return to a similar level as in 1995 and thereafter slowly grow. We assume that 1996 was just a break in the development of wind power but it is extremely difficult to predict whether the market will reach the same level already in 1997 or maybe not until 1998. The most busy period of time in India is normally the 1st quarter of the year which is a good indicator of how well it will go. The 3rd quarter is normally the second best of the year. This is due to the tax regulations in India and their fiscal year that ends 31st of March. There is still a large need for additional electricity in India which means that the need for wind power is still the same as a year or two ago.

⁹ This is presently not the case in the USA.

- Development in **China** has slowly increased over the past couple of years and several large projects are planned to be installed during 1997. Both national and regional plans include large numbers of wind power capacity in the future energy mix which indicates good possibilities for a large market in the future.

4.1 Prognosis for market development until 2001

Table 4-1 shows our prognosis between 1997-2001. This prognosis will end up with some 3,000 MW of new installed capacity per year and an accumulated capacity of 17,500 MW by the end of 2001. Figure 4-1 shows annual global development between 1990-1996 and how it looks until the year 2001 according to the prognosis in table 4-1. Figure 4-2 compares the accumulated installed capacity by the end of 1996 with the estimated numbers by the end of the year 2001. The most significant change is that the USA market share will still decrease while Asia and 'other markets' will take over a much bigger part of the global wind power capacity. Europe will maintain a leading position with more than half of the installed wind power capacity globally.

Table 4-1: Prognosis for wind power development 1997-2001

	Accu. installed capacity (MW) by end of 1996	Installed capacity (MW) in 1996	Prognosis 1997-2001					Installed capacity between 1997- 2001	Accu. installed capacity (MW) by end of 2001
	1996	1996	1997	1998	1999	2000	2001	Sum	Accu.
USA	1,596	12	150	150	150	200	400	1,050	2,646
Canada	21	0	20	30	50	100	100	300	321
Latin America	34	22	50	50	50	100	120	370	404
Total America	1,651	34	220	230	250	400	620	1,720	3,371

Denmark	835	200	150	125	125	150	150	700	1,535
Finland	7	1	10	10	10	10	20	60	67
Germany	1,552	420	300	300	300	300	300	1,500	3,052
Greece	29	1	40	50	50	50	50	240	269
Italy	71	38	40	40	40	40	50	210	281
Rep. Ireland	11	4	20	30	30	30	50	160	171
Netherlands	299	50	50	50	50	50	100	300	599
Portugal	19	11	10	10	10	10	20	60	79
Spain	249	116	200	250	250	250	250	1,200	1,449
Sweden	103	34	30	50	50	100	100	330	433
UK	273	73	100	100	150	100	100	550	823
Other European countries: Belgium /Czech Rep. /Slo- vak Rep. /France / Norway /Austria /Switzerland /other East European countries.	49	20	50	100	125	125	200	600	649
Total Europe	3,496	967	1,000	1,115	1,190	1,215	1,390	5,910	9,406

P.R. China	79	35	100	150	150	150	200	750	829
India	820	244	200	300	500	500	500	2,000	2,820
Other Asian countries: Korea / Japan / Malaysia/Indonesia / Thailand/ Vietnam etc.	13	3	10	50	50	50	75	235	248
Total Asia	912	282	310	500	700	700	775	2,985	3,897

Australia & New Zealand	6	4	10	20	20	20	30	100	106
North Africa - including: Egypt, Ethiopia, Libya, Tunis, Algeria, Morocco.	9	0	30	100	75	75	75	355	364
Middle East - including : Jor- dan/ Syria/ Israel/ Saudi Ara- bia/ Iran/ Iraq. (excl. Egypt)	10	2	20	20	30	30	30	130	140
Former Soviet Union: FSU- countries	18	1	10	10	20	20	50	110	128
Rest of the world	3	3	20	20	20	20	20	100	103
Total other continents and areas:	46	9	90	170	165	165	205	795	841
Total MW new capacity every year:		1,292	1,620	2,015	2,305	2,480	2,990	11,410	17,514

Accu. capacity (MW)	6,104
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Source: BTM Consult ApS - March 1997

7,724	9,739	12,044	14,524	17,514
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Figure 4-1: Prognosis for the years 1997-2000

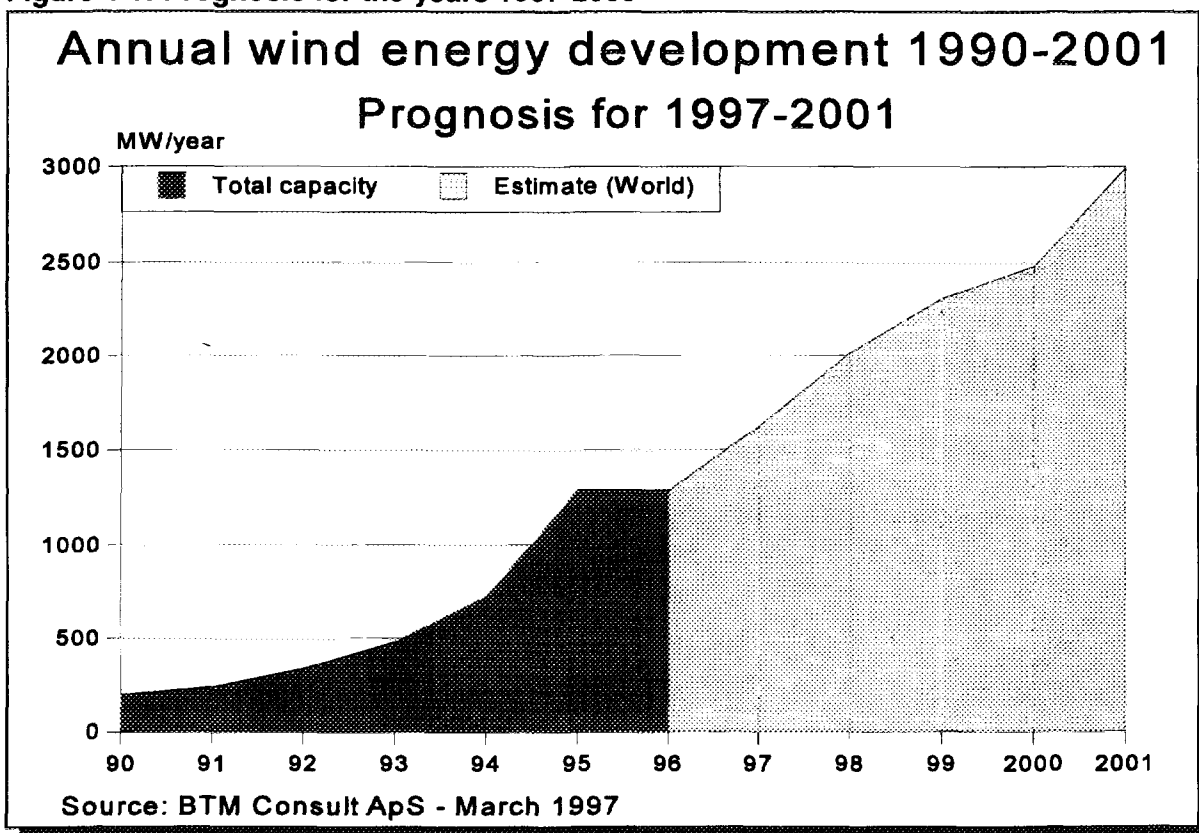


Figure 4-2: Accu. installed capacity by the end of 1996 and prognosis by 2001

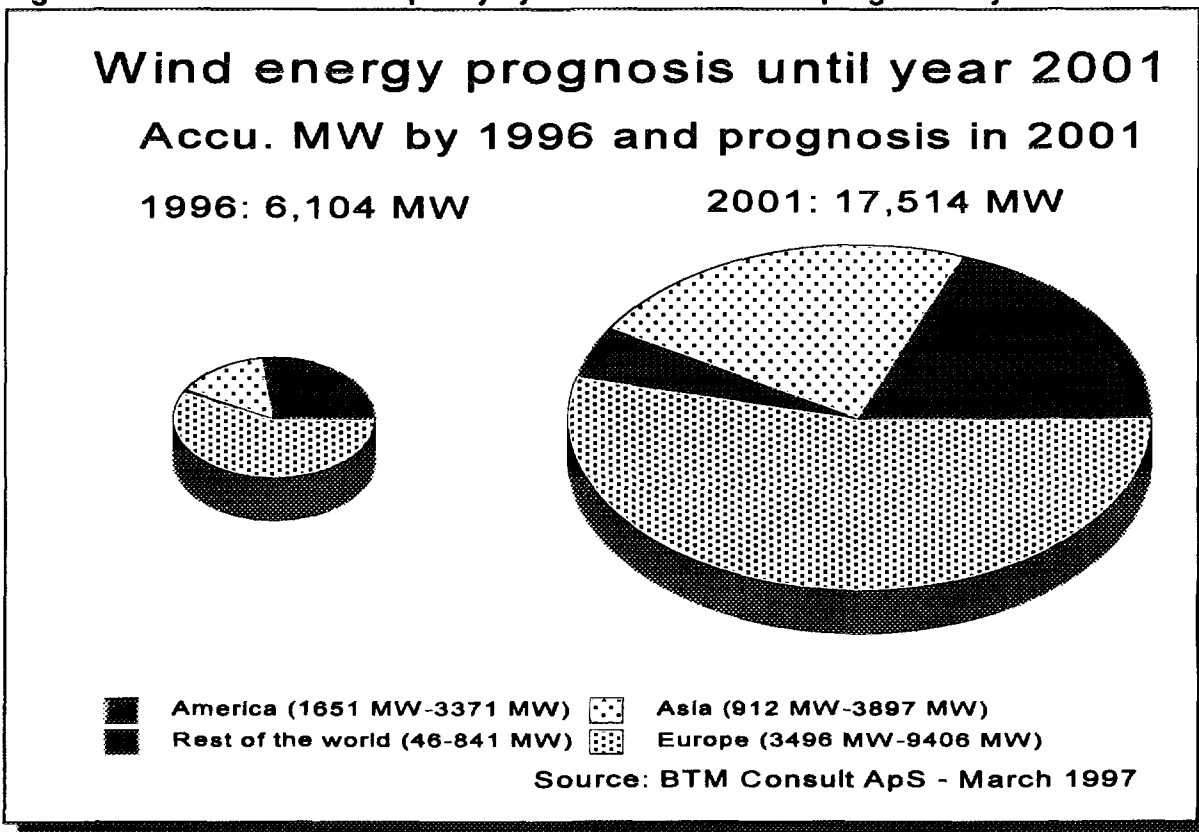
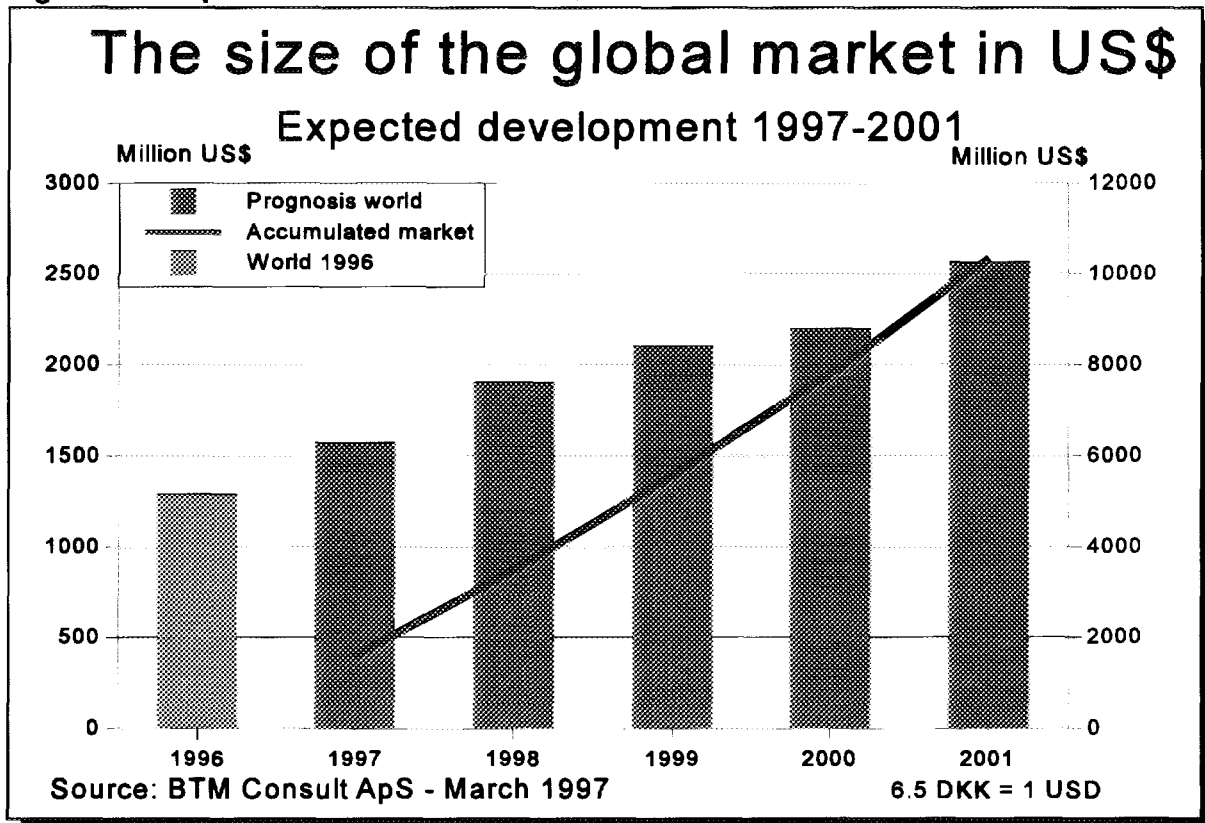


Figure 4-3 shows the size of the global wind power market in terms of USD. The 1996 numbers are based on actual installed MW's and a price of USD 1 mill. per installed MW¹⁰. An average price reduction of 3% per year is used in the calculations to estimate future sales between 1997-2001. A higher price reduction might occur some years like e.g. 1995/96 when the new 600 kW machines were introduced to the market for almost the same price as the previous 500 kW machines the year before. The opposite might also occur and the new MW size wind turbines does not so far indicate a lower price per MW than 600 kW machines in the market today. That is why our average of 3% p.a. should be viewed as an average for the whole industry on a 5 years forecast.

Figure 4-3: Expected world market in US\$



USD 1 mill. per installed MW are used in the data for 1996 shown in figure 4-3 and the calculations for 1997-2001 are based on an annual decline of 3% p.a. which will reduce the price to USD 0.86 mill. per installed MW by the year 2001. World sales of wind turbines were roughly USD 1.3 billion in 1996 which is expected to reach USD 1.6 billion in 1997. The growth is expected to continue until the year 2001 where it will reach USD 2.4 billion. Accumulated sales between 1997-2001 is expected to account for some USD 10 billion.

4.2 Manufacturers capability versus market demands

There is an excess capacity of manufacturers among the 10 leading suppliers if the market

¹⁰ A common 600 kW WTG costs around 3.9 mill. DKK (total installed cost) in Denmark.

prognosis shown in chapter 4.1 is compared to the present manufacturing capacity. The total manufacturing capacity today is in the area of 35-40 per cent higher than actual market demands. It is our estimate that there are a present capacity among the manufacturers to cope with a world wide demand of approx. 2,300 MW without any major investments in new manufacturing facilities.

Based upon the above, it is expected that the marketplace will see fierce competition among the manufacturers now and in the near future. It is estimated that the 5 biggest wind turbine manufacturers in the world could supply all wind turbines installed during 1995 and 1996. The annual global market for wind power is not expected to exceed 2,300 MW per year, until the year 1999.

4.3 Expected development until the year 2005

Expected wind power development after the year 2001 - here called estimate - is not based on actual political decisions, but do rather reflect our analysis of the political climate regarding energy supply at the turn of the century. The rapid economic growth in Asia will continue at least through the first decade of the next century. Other parts of the world outside OECD is likely to show economic growth and increase their demand for electricity. Among the OECD countries the concern about global warming is expected to be important on the political agenda, after it has been verified that the intention of the Rio Declaration is far away from realization.

The intention of the Rio Declaration was to stop further increase of CO₂ emission by the year 2000 and thereafter initiate a reduction. Talks within the IPCC (Intergovernmental Panel on Climate Change) during 1996/97 emphasize the need for commitments to exact reduction goals in terms of quantified reduction figures. Such a commitment has top priority at the so-called 3rd Conference of Parties in December of 1997, to be held in Japan. Both drivers "energy need" and "environmental awareness" are likely to be accelerated by the turn of the century - leaving the wind industry with very good market perspectives due to its competitiveness in delivering CO₂-free electricity at a low price.

Figure 4-4 shows estimated development between 2001-2005 which is a lot more uncertain than the prognosis for 1997-2001. Figure 4-5 show the distribution of installed capacity by the end of the year 2001 and 2005, based on the prognosis and estimates respectively.

Figure 4-6 shows the growth of accumulated installed wind power capacity worldwide between 1990-1996 and the expected development until the year 2001 (prognosis) and 2005 (estimate).

The accumulated installed capacity were 6,104 MW by the end of 1996 which is expected to increase to some 17,500 MW by the end of the year 2001 and almost 34,000 MW by the end of the year 2005.

Figure 4-4: Actual 1990-1996 - Prognosis 1997-2000 - Estimate 2001-2005

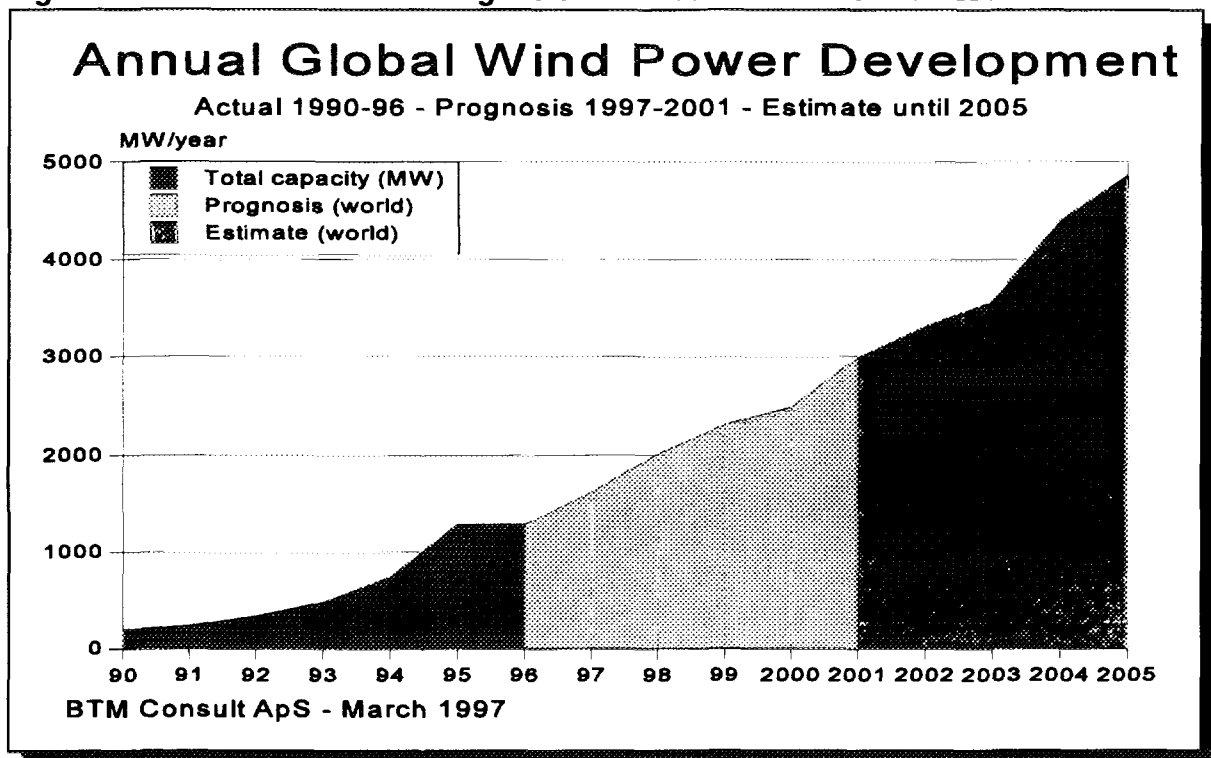


Figure 4-5: Prognosis for accu. installed capacity by year 2001 and estimate by 2005

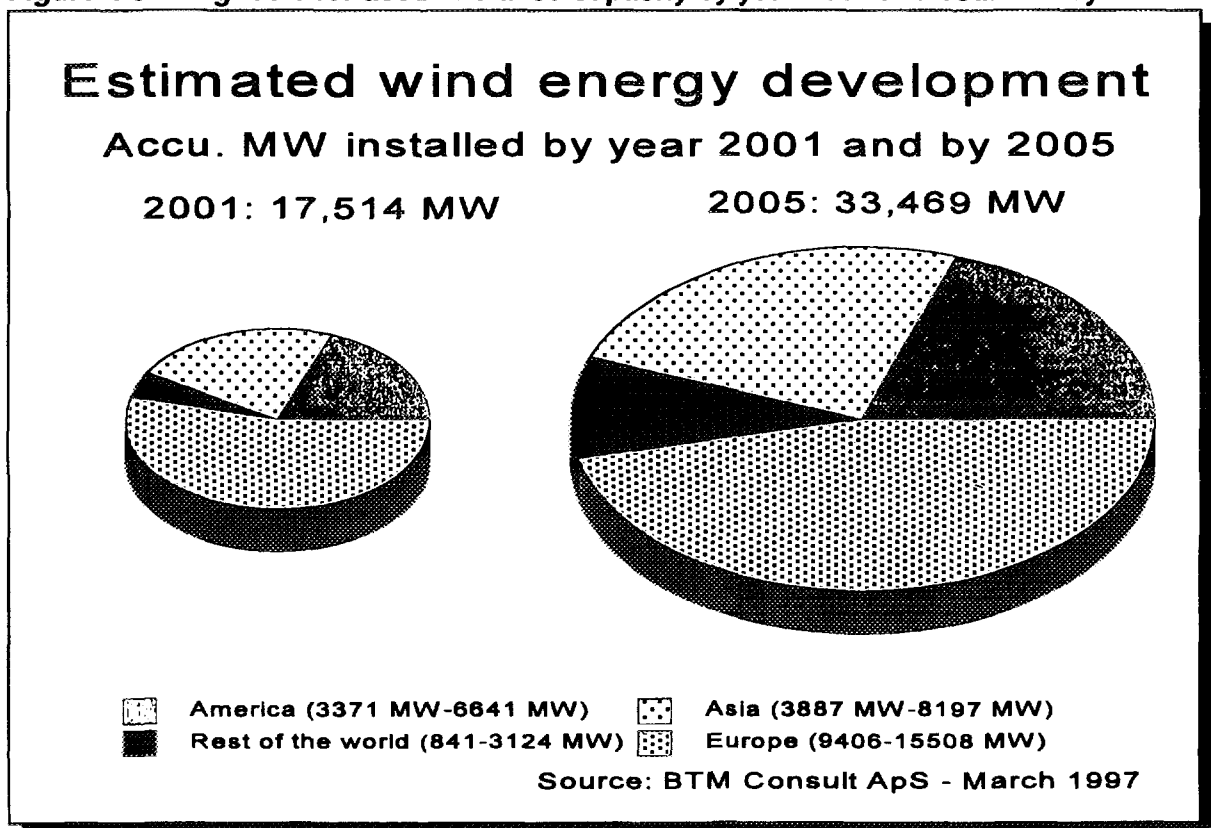
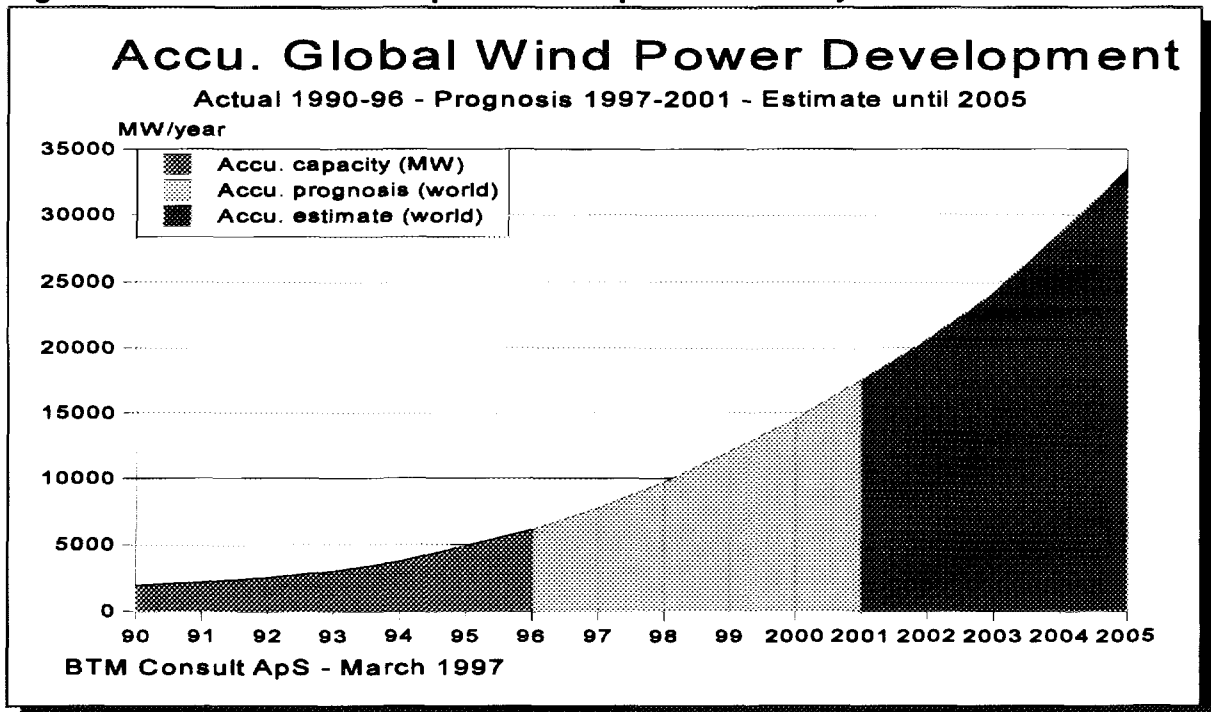


Figure 4-6: Accumulated wind power development until the year 2005**Other market forecasts and/or predictions:**

Other international organizations and statistic publishers has released forecasts for the potential of renewable energy and for wind energy penetration in the future. Among those are:

WEC (World Energy Council)

180,000 MW of Wind Power by the year 2020.

IEA (International Energy Agency)

Some 60-80,000 MW from different renewable sources such as Wave-, Geothermal-, Solar- and Wind power by the year 2010. About half of this capacity may come from Wind Power installations (BTM-C judgement).

EU (European Union)

8,000 MW of Wind Energy within EU-15 by the year 2005 (Goal of the "Altener Programme", when started in 1992).

EWEA (European Wind Energy Association)

4,000 MW by the year 2000 in the EU-15 countries

11,500 MW by the year 2005 in the EU-15 countries

100,000 MW by the year 2030 in the EU

(Source: Time for Action published in 1991)

AWEA (American Wind Energy Association)

4,500 MW by the year 2005 in the US (Press Release by April 12, 1996)

5. Nature of different market segments and drivers

Since the beginning of modern wind power utilization, the market has been highly dependent on the political situation and willingness to support this power technology in return of a cleaner environment. This is still the case in most of the main markets today but other aspects are finally starting to play an important part. The cost effectiveness of modern wind turbines has improved significantly over the years and has opened new markets for this technology.

Wind energy is mainly viewed in the western part of the world as a supplement to reduce the CO₂ emission while developing countries can benefit from wind energy in other ways as well.

The market drivers in Asia (China, India, etc.) and other similar parts of the world are an urgent need for energy linked to a more and less rapid growth of local economy. For several years we have seen economic growth rates (GNP-growth) of the magnitude of 5-10% per year. Highest in China (10% per year) and for India some 5-6% per year. The result of this growth is an urgent need for electricity. Even in cases where wind energy is not the cheapest way of getting new electric capacity it may be chosen due to the fact that it can be installed dispersed (where the need is) and in a very rapid way. The demand for electricity will of course be met mainly from traditional sources (such as coal and gas), but a contribution of a few per cent from renewables will create significant market opportunities for the wind power industry. Typically for the same countries are their desire of local manufacturing of the wind turbines, challenging the industry to go into joint ventures including technology transfer.

5.1 Environmental & Energy driven markets

The characteristics of these new markets mentioned above, makes it logic to divide the world market into two main categories linked to economic growth and development status for each region(s). These two market categories are: '*Energy Driven Markets*' (mainly Asia, South America & Africa) and '*Environmental Driven Markets*' (mainly OECD-countries). Table 5-1 on the following page shows a more detailed list of countries included in each category.

Energy Driven Markets will especially become more important although the Environmental Driven Markets are estimated to contribute with the largest part in the periode between 1997-2001. Local manufacturing of wind turbines via joint ventures and the ability/willingness to assist in technology transfer will also become essential factors in these markets for the future. Figure 5-1 shows expected development between 1997-2001 for Environmental Driven Markets and Energy Driven Markets.

These market segments are further described in table 5-2 where examples are presented of places in the world where such market segments have been experienced over the years. It is expected that new markets will follow similar development patterns as seen in other countries throughout the years.

More specific market segments are present in both the Energy Driven Market and the Environmental Driven Market which is further described in chapter 5.2.

Table 5-1: Current and developing markets for wind energy - Market segments

World Market for Wind Energy 1996-2001	
Environmental Driven Markets Mainly OECD - countries	Energy Driven Markets Mainly Africa, Asia and Latin America
Market characteristic No need for additional capacity. Financially able to invest. Wind energy development only contributes with a very small part of the total budget for the whole energy sector. Political interest and obligation to reduce CO ₂ -emission. Wind energy development is <u>not very sensitive</u> to variations in international fuel prices.	Market characteristic Immediate need for additional energy - especially electricity. Capacity shortfall. Depending on import of fossil fuel, in best case self sufficient today. Shortage of foreign currency. Moderate to high economic growth (South and East Asia). Higher average increase in population, economic growth and energy consumption than OECD-countries. Need for technology transfer and local production. <u>Very sensitive</u> for variations in international fuel prices - in favour for wind energy.
EU-countries: Germany England (UK) Holland Denmark Italy Ireland Greece Spain Portugal Finland Sweden Austria Norway America: USA Canada Caribbean Islands Pacific area: Australia, New Zealand Some islands in the Pacific Ocean Asia: Japan, Taiwan, Malaysia	Africa: Egypt Cape Verde Morocco Libya Asia: India China North Korea Indonesia Thailand Vietnam South America: Argentina Brazil Chile Bolivia Central America: Costa Rica Mexico Nicaragua
These markets are expected to be increased by 7,595 MW of new installed wind power capacity between the year 1997-2001. Status by end of 1996: 5,131 MW	These markets are expected to be increased by 3,475 MW of new installed wind power capacity between the year 1997-2001. Status by end of 1996: 942 MW
Other markets: Between 1997-2001 an additional 340 MW will be installed throughout the world. This will mainly be in the Middle East and FSU-countries. It is a very uncertain market. Since the FSU countries changed to market economy, they have experienced a decrease in the energy consumption and they still possess large reserves of fossil fuel. The Middle East countries have no acute need for additional energy nor political environmental goals.	

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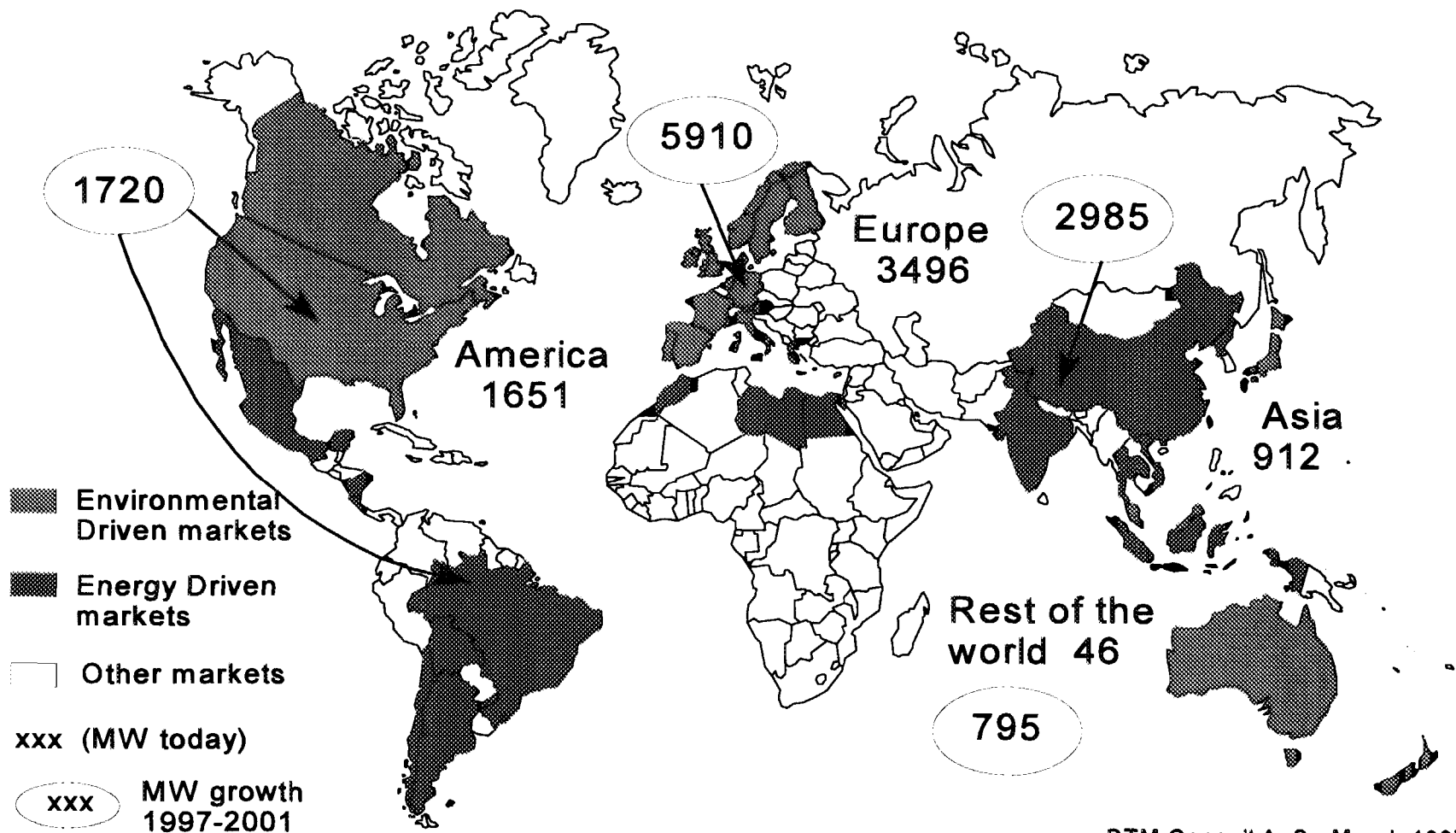
Table 5-2: Market Segments and Customers

Description of different market segments	Customers	Existing markets and potential newcomers
<p>1. Private owned WTG - 150 kW to 1.5 MW :</p> <p>Smaller projects in the size between 1-5 units. Usually owned by one or few investors.</p>	<p>Small Cooperatives Farmers Industrial factories</p>	<p>Denmark Holland Sweden Germany Lately also in the USA</p>
<p>2. Commercial wind farms < 5 MW:</p> <p>Clusters or smaller wind farms with between 10-20 WTG, owned by several investors.</p>	<p>Larger Cooperatives Industrial factories Investment groups</p>	<p>Denmark Germany India UK</p>
<p>3. Private wind farms < 100 MW:</p> <p>Large projects established by specialized developers, with a main objective to build and operate such projects</p>	<p>Independent Power Producers (IPP) Professional electricity producers</p>	<p>USA UK Spain On its way in Germany</p>
<p>4. Utility owned wind farms in the size 5-100 MW</p> <p>Normally larger projects where the electricity from wind power is included in the overall generation mix.</p>	<p>Utilities often buys the WTG directly or as a bidding process. Sometimes as a turn-key project. The market is still rather small globally.</p>	<p>Denmark USA UK China Holland</p>
<p>5. Joint-venture, Type I</p> <p>Sales, assembling and service. Limited technology transfer. Could be the first step to Type II depending on present conditions.</p>	<p>Private companies/factories Industrial entities</p>	<p>Spain India Egypt China</p>
<p>6. Joint-venture, Type II</p> <p>Similar to Type I but does also include local manufacturing and more technology transfer.</p>	<p>Private companies/factories Industrial entities</p>	<p>India Spain USA (still only small scale) China Egypt</p>
<p>7. Niche markets</p> <p>Rural areas with only little or no infrastructure.</p>	<p>Development aid and often tailor made assignments. Customers are often international aid organisations.</p>	<p>Developing countries Arctic areas Middle East</p>
<p>8. Off-Shore projects</p> <p>Still mainly pilot projects.</p>	<p>R&D with utilities who are expected to become main customers in the future.</p>	<p>Denmark Holland Germany UK</p>

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Prognosis for wind energy development 1997-2001

Figure 5-1: Status 1996 and prognosis 1997-2001 divided between market drivers



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Figure 5-1 shows the distribution of installed wind power capacity by the end of 1996 between Environmental Driven Markets (green) and Energy Driven Markets (red). It also shows the numbers of MW's expected to be installed between 1997-2001. Some countries have not been categorized due to several factors which has made it difficult to put them in the one or the other category. These countries has no color on the map.

5.2 Market segments characterized by size, etc.

The different market segments for wind power development can be described based on experiences from all over the world during the last 20 years. These segment can be divide in terms of size, customers and potential for future development in both existing and new markets. Most of the segments exist in both Energy Driven Markets and Environmental Driven Markets although the potential for each segment varies. The main categories are listed below:

- **Single owned WTGs in the size between 150 kW to 1.5 MW**
- **Commercial owned (Cooperatives) wind farms up to 5 MW**
- **Private developers, wind farms up to 100 MW**
- **Utility owned wind farms in the size 5-100 MW**
- **Joint-ventures - Type 1: sales, assembling and service of WTGs**
- **Joint-ventures - Type 2: local manufacturing of WTGs and everything else which is included in type 1.**
- **Niche markets: Stand-Alone, Wind-Diesel, Fresh water production, Telecommunication, Ice production and Hybrid systems.**
- **Off-Shore projects**

Both types of joint ventures are not market segments by itself but part of a necessary process to reach the market potential in certain countries. Off-shore development has until today only been installed in few places and is still part of the niche market. Table 5-3 shows an estimate of the size of the different market segments based on global wind power development in 1994, 1995 and 1996.

Table 5-3: Segment distribution of installed capacity in 1994-1996

Market segments	% of world market in 1994	% of world market in 1995	% of world market in 1996
Private owned WTG: 150 kW to 1.5 MW	35	52	49
Commercial wind farms: < 5 MW	32	23	21
Private wind farms: < 100 MW	22	14	18
Utility owned wind farms: < 100 MW	10	10	10
Niche markets	1	1	1

Source: BTM Consult ApS - March 1997

The future market for global wind power development can be divided into two different major categories based on the prognosis shown in table 4-1. These categories are: Environmental Driven Markets and Energy Driven Markets which has been described earlier. An attempt has been made in table 5-4 to quantify the market potential for wind power development for each of the different segments. It represents a picture of how it is estimated that the distribution between segments and markets will appear in the year 2001. This might therefore not necessarily represent the situation today or next year.

Table 5-4: Likely distribution of market segments in the year 2001

Environmental Driven Markets	% of this segment
1. Private owned WTG: 150 kW to 1.5 MW	7
2. Commercial wind farms: < 5 MW	17
3. Private wind farms: < 100 MW	34
4. Utility owned wind farms: 5-100 MW	34
5. Off-shore projects	6
6. Niche markets	2
Total market share (60% of the global market)	100
7. Joint-ventures (Type I & II) contributes with:	20
Energy Driven Markets	% of this segment
1. Private owned WTG: 150 kW to 1.5 MW	20
2. Commercial wind farms: < 5 MW	40
3. Private wind farms: < 100 MW	17
4. Utility owned wind farms: 5-100 MW	20
5. Off-shore projects	0
6. Niche markets	3
Total market share (40% of the global market)	100
7. Joint-ventures (Type I & II) contributes with:	80

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The global potential for wind energy development is estimated to some 11,410 MW of new installed capacity between 1997-2001, both years included. Around 3,500 MW will according to the estimate in table 5-4 be installed in those countries representing Energy Driven Markets. This means that some 65% of the global market is still represented among the Environmental Driven Markets, such as the industrialized countries (OECD, IEA, etc.). The contribution from the Former Soviet Union and the Middle East countries is not included in these numbers which only adds up to some 340 MW extra capacity or just around 3% of the total.

International sales via joint-ventures are estimated to contribute with 20% of the potential in the Environmental Driven Markets, whereas this segment is much higher (80%) for the Energy Driven Markets. This means that close to 40% of the total market between 1997-2001 will be supplied via local joint ventures.

Appendices

Appendix A: Installed capacity in Denmark and the USA

Appendix B: Installed capacity in Germany and the UK

Appendix C: Installed capacity in India and Spain

Appendix D: Installed capacity in Sweden and the Netherlands

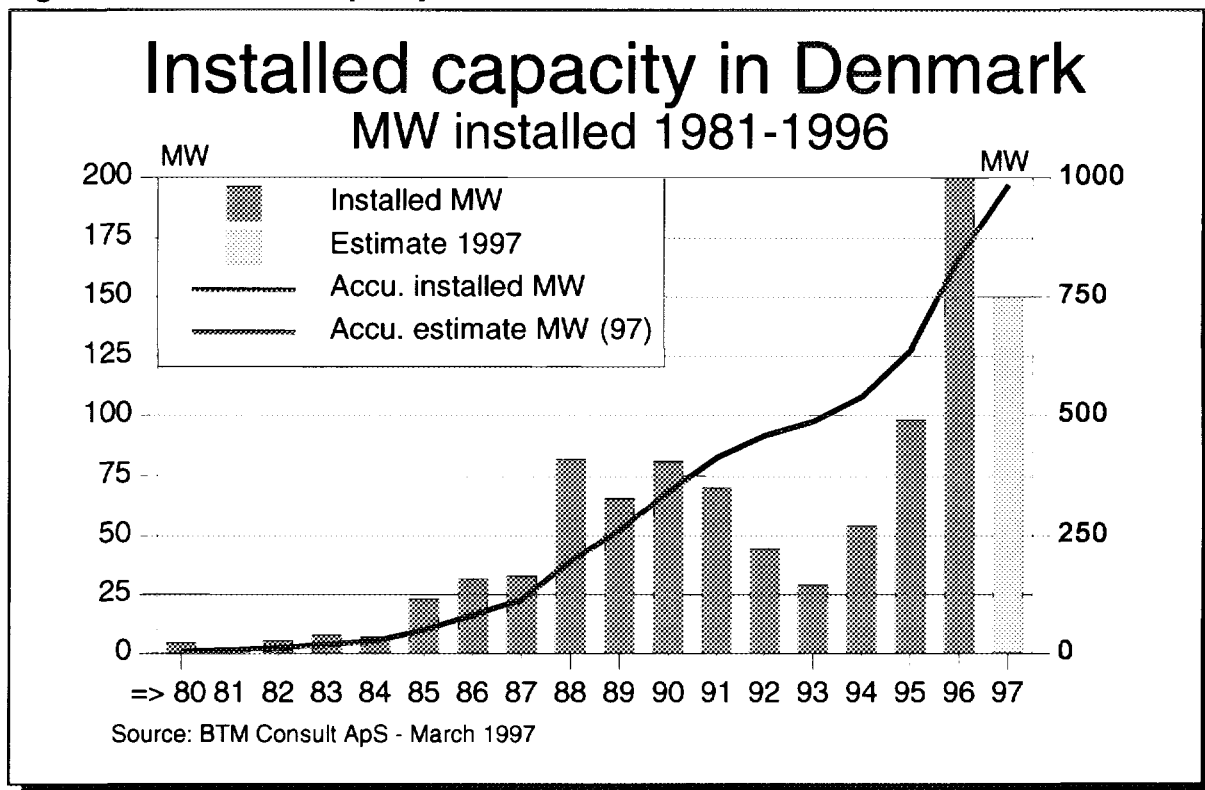
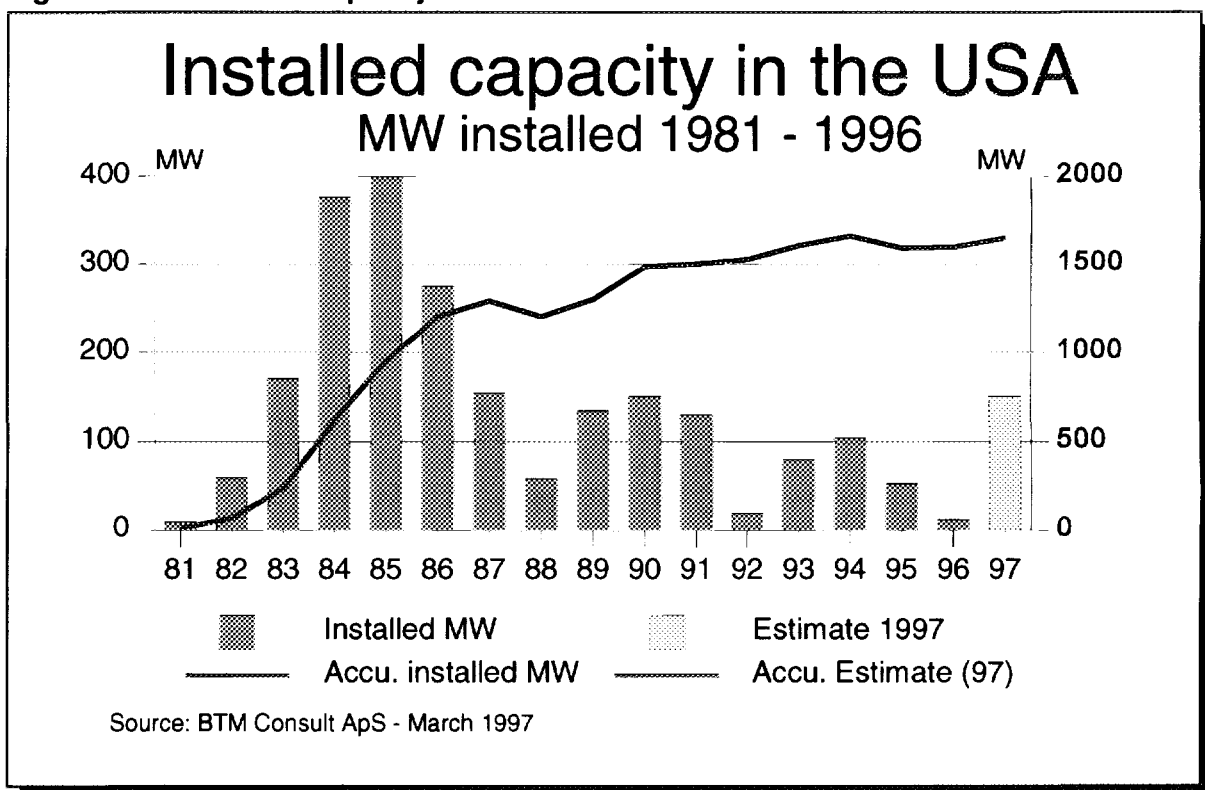
Appendix E: Manufacturers market share in 7 countries during 1996

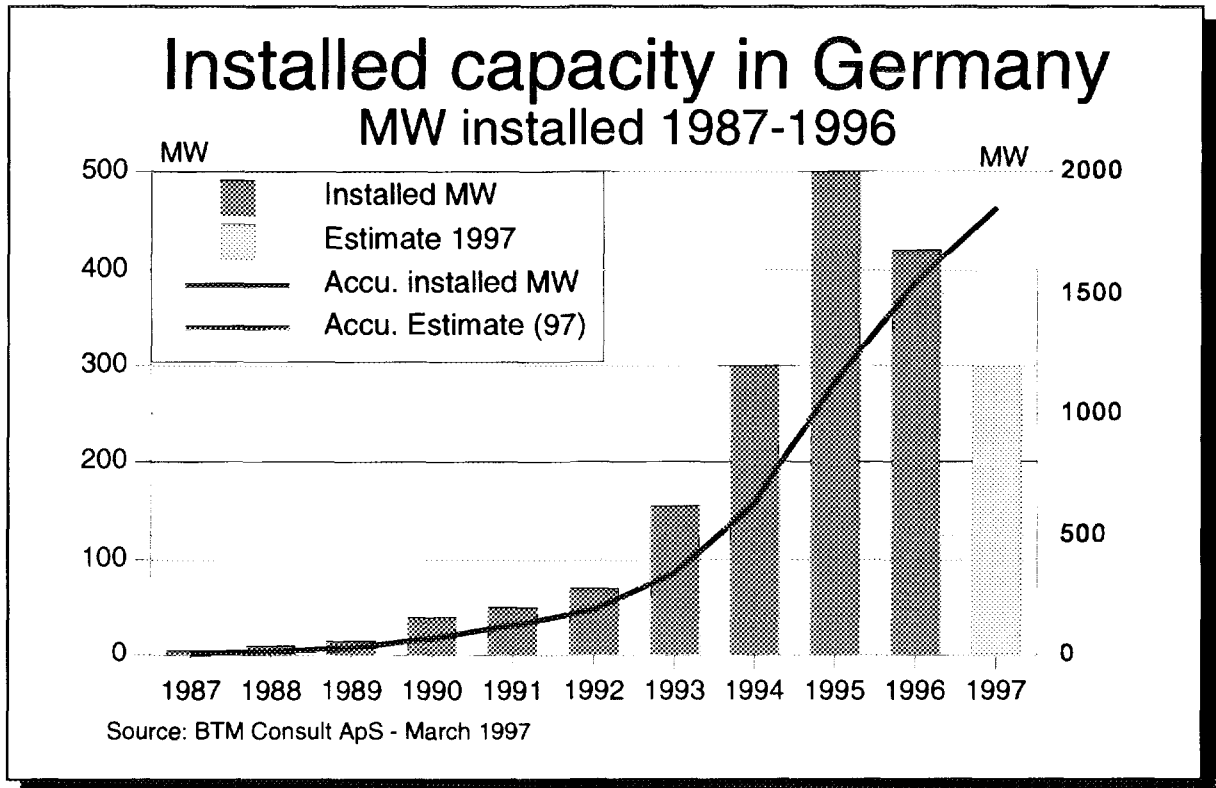
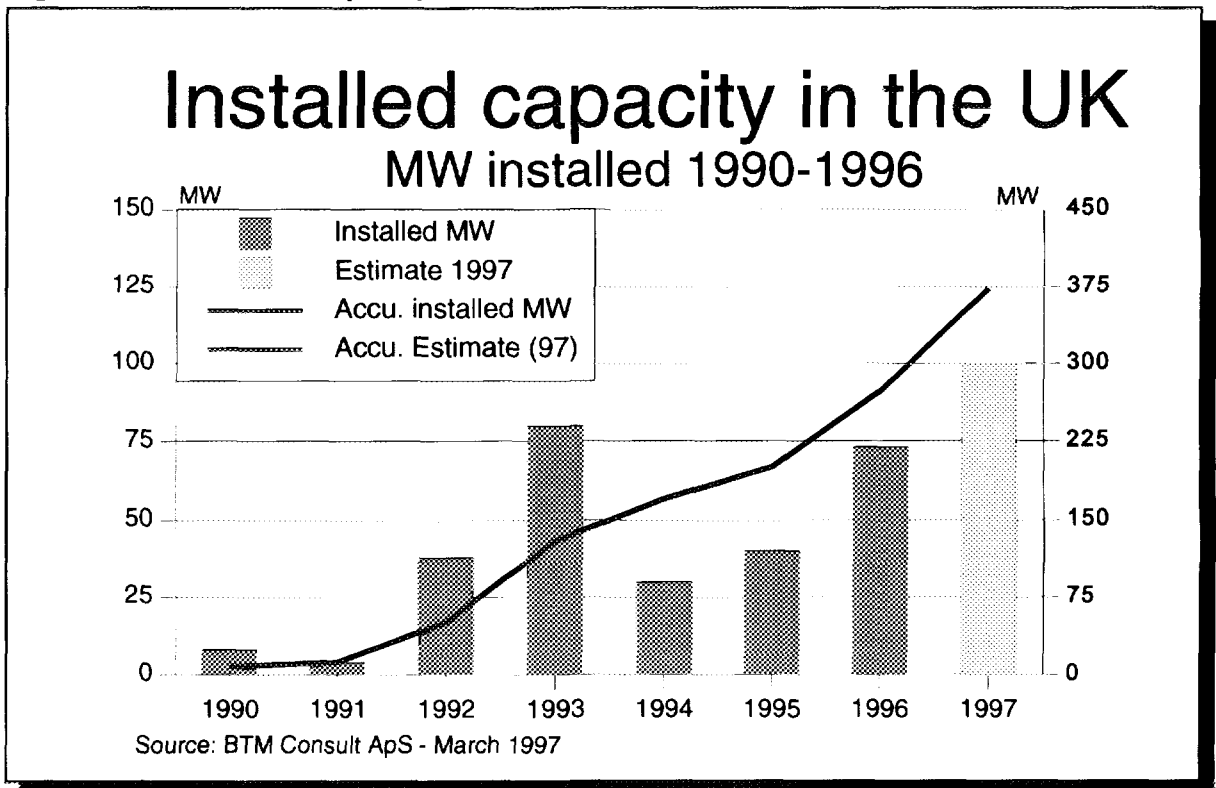
Appendix F: Wind turbine manufacturers

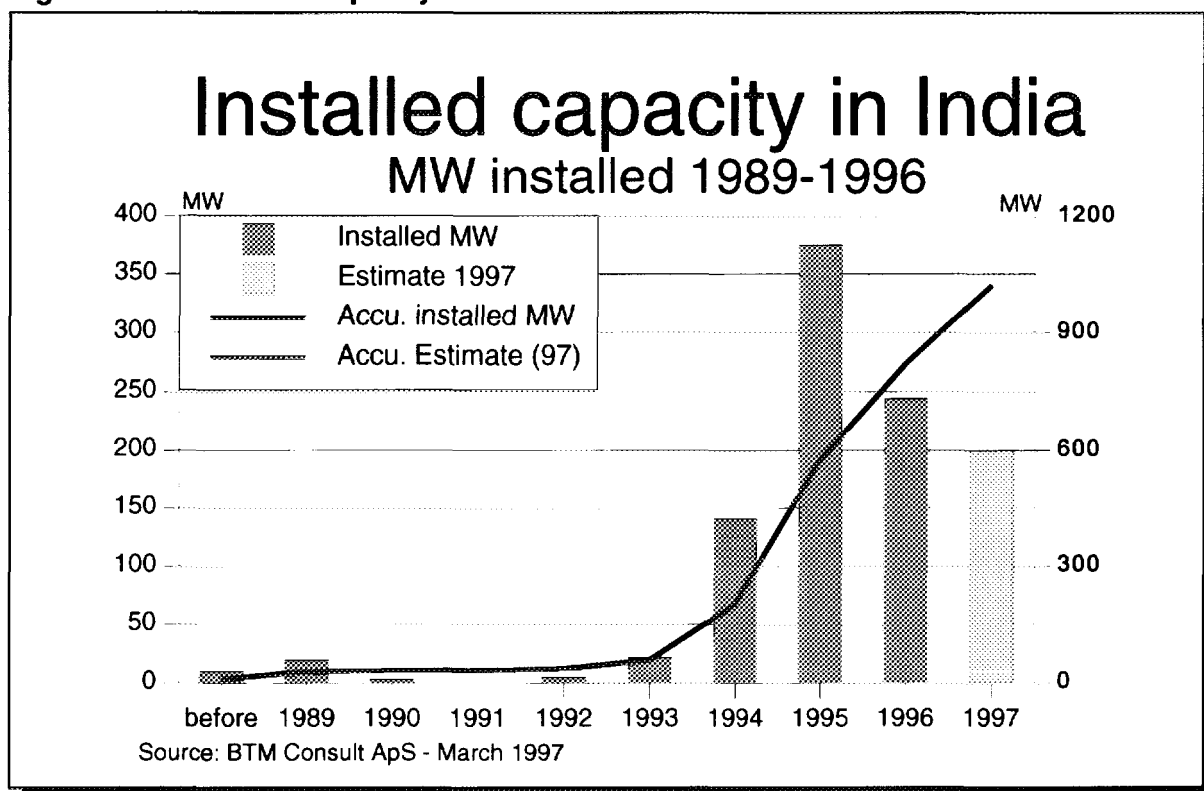
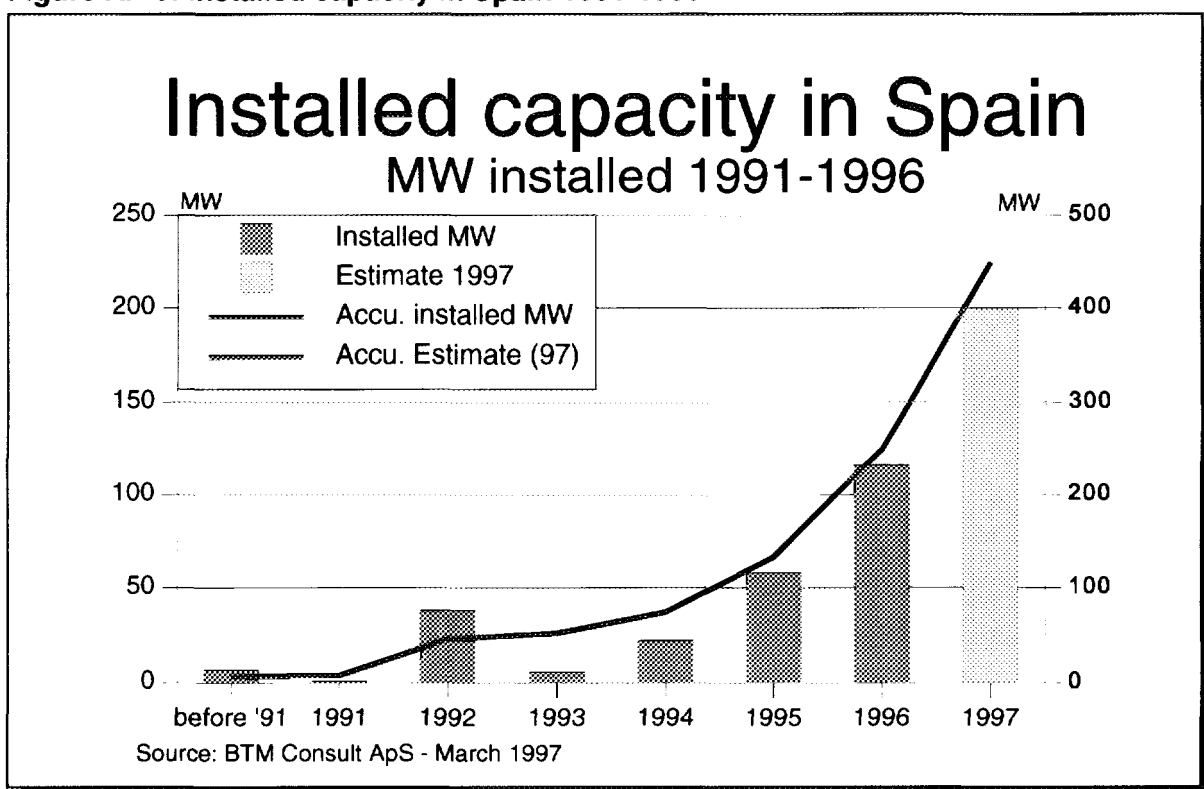
Appendix G: Abbreviations and technical units

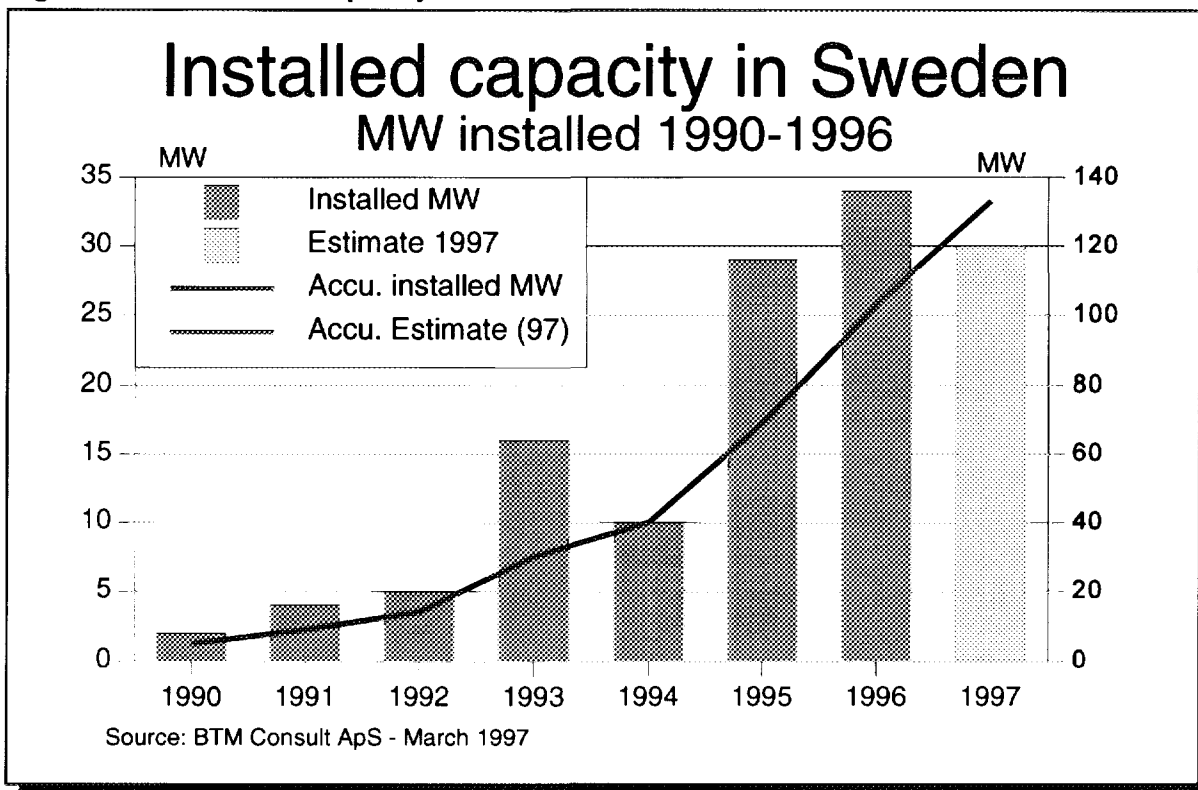
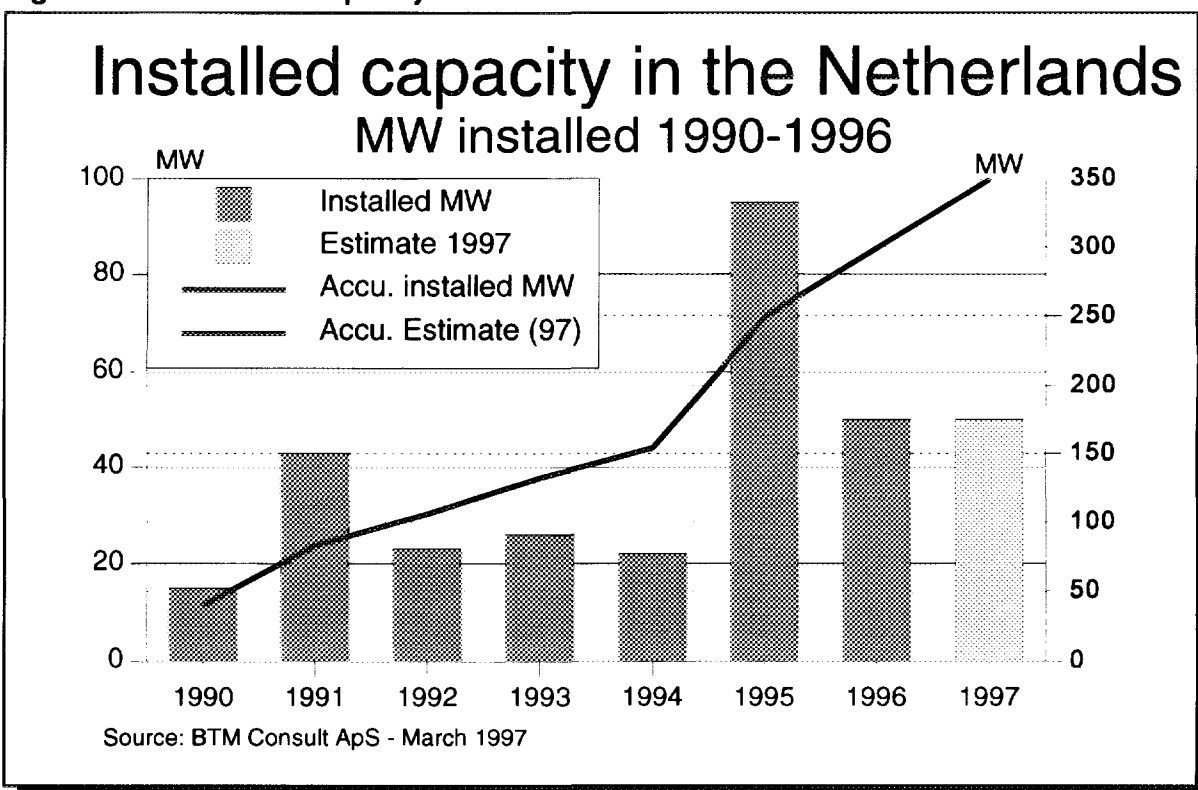
Appendix H: Comments and changes

Appendix I: BTM Consult ApS company profile

A: Installed capacity in Denmark and the USA**Figure AP-1: Installed capacity in Denmark 1980-1996****Figure AP-2: Installed capacity in the USA 1981-1996**

B: Installed capacity in Germany and the UK**Figure AP-3: Installed capacity in Germany 1987-1996****Figure AP-4: Installed capacity in the UK 1990-1996**

C: Installed capacity in India and Spain**Figure AP-5: Installed capacity in India 1989-1996****Figure AP-6: Installed capacity in Spain 1991-1996**

D: Installed capacity in Sweden and the Netherlands**Figure AP-7: Installed capacity in Sweden 1990-1996****Figure AP-8: Installed capacity in the Netherlands 1990-1996**

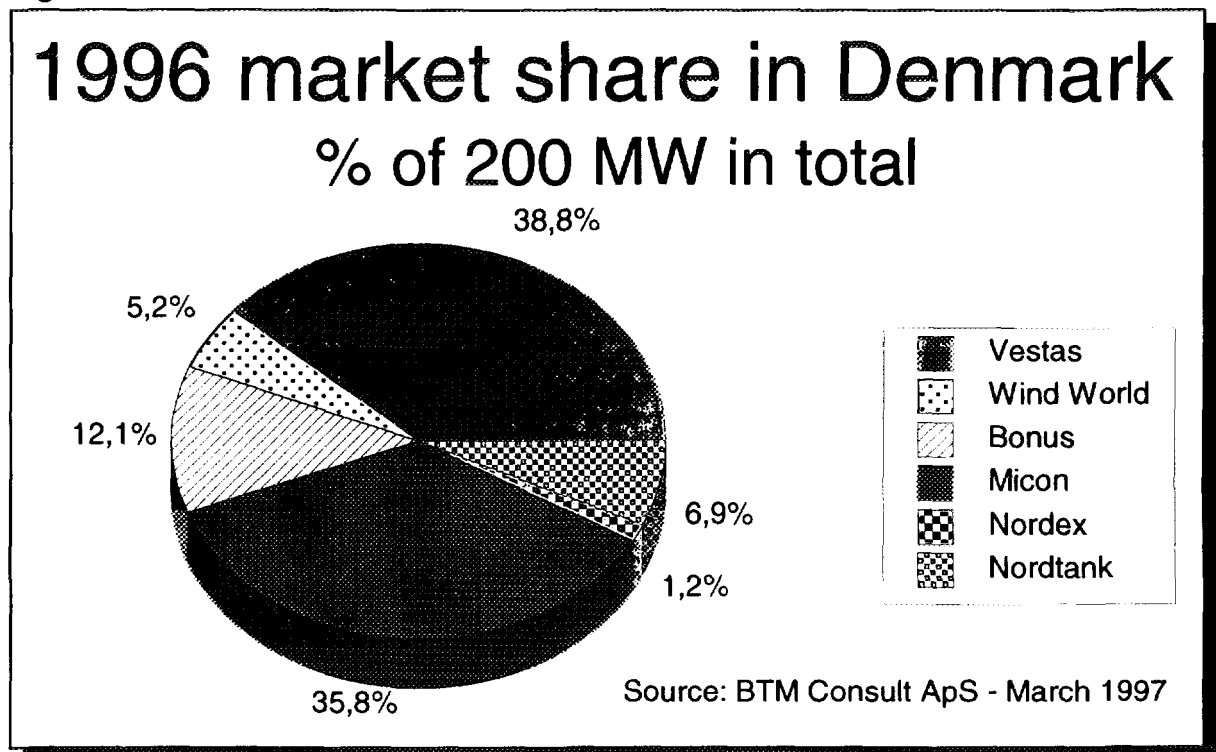
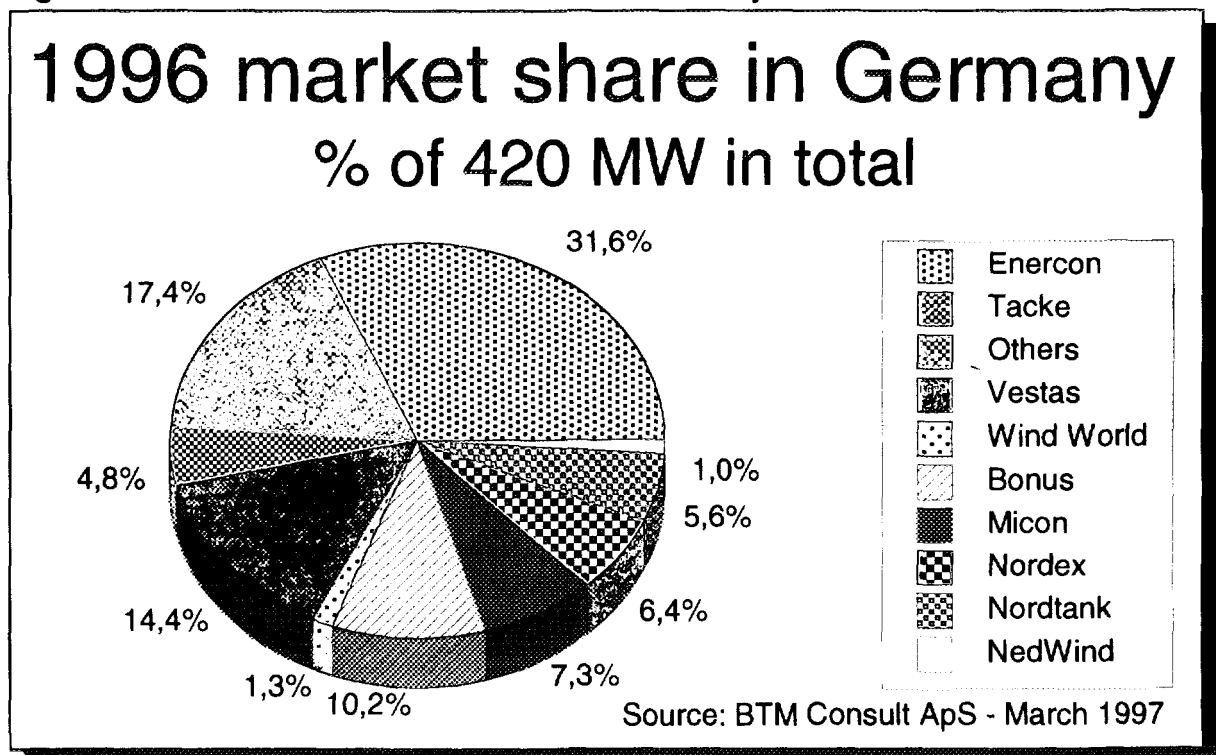
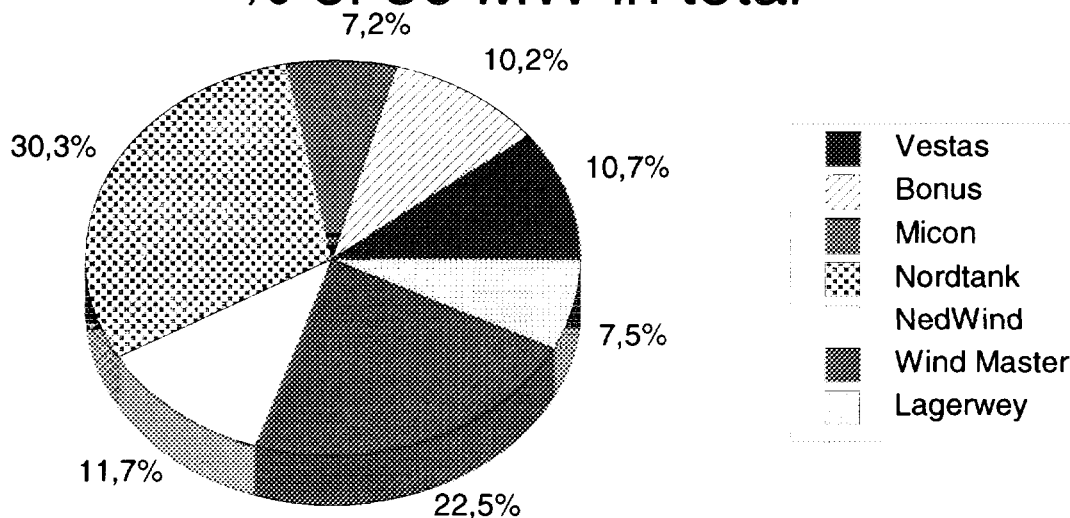
E: Manufacturers market share in 7 countries during 1996**Figure AP-9: Manufacturers market share in Denmark 1996****Figure AP-10: Manufacturers market share in Germany 1996**

Figure AP-11: Manufacturers market share in the Netherlands 1996

1996 market share in Netherlands

% of 50 MW in total

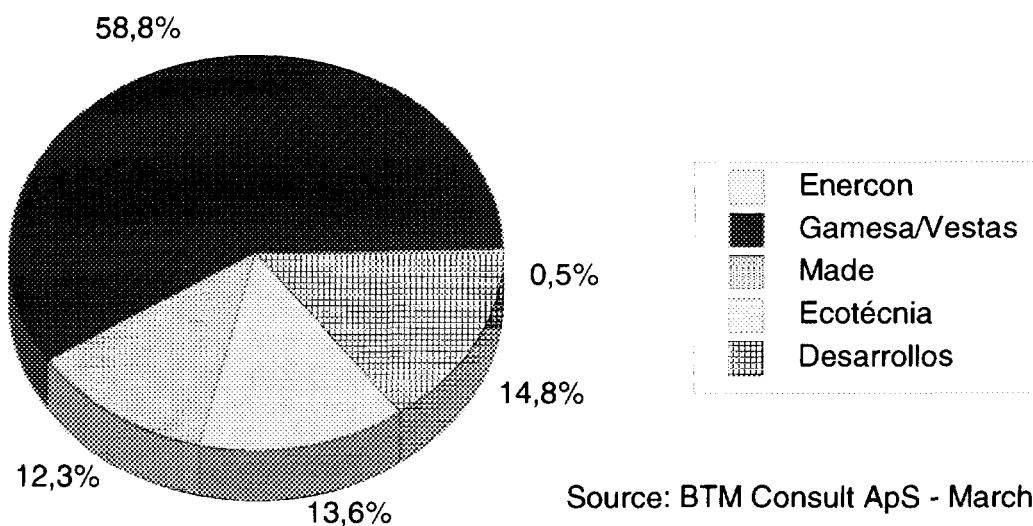


Source: BTM Consult ApS - March 1997

Figure AP-12: Manufacturers market share in Spain 1996

1996 market share in Spain

% of 116 MW in total



Source: BTM Consult ApS - March 1997

Figure AP-13: Manufacturers market share in Sweden 1996

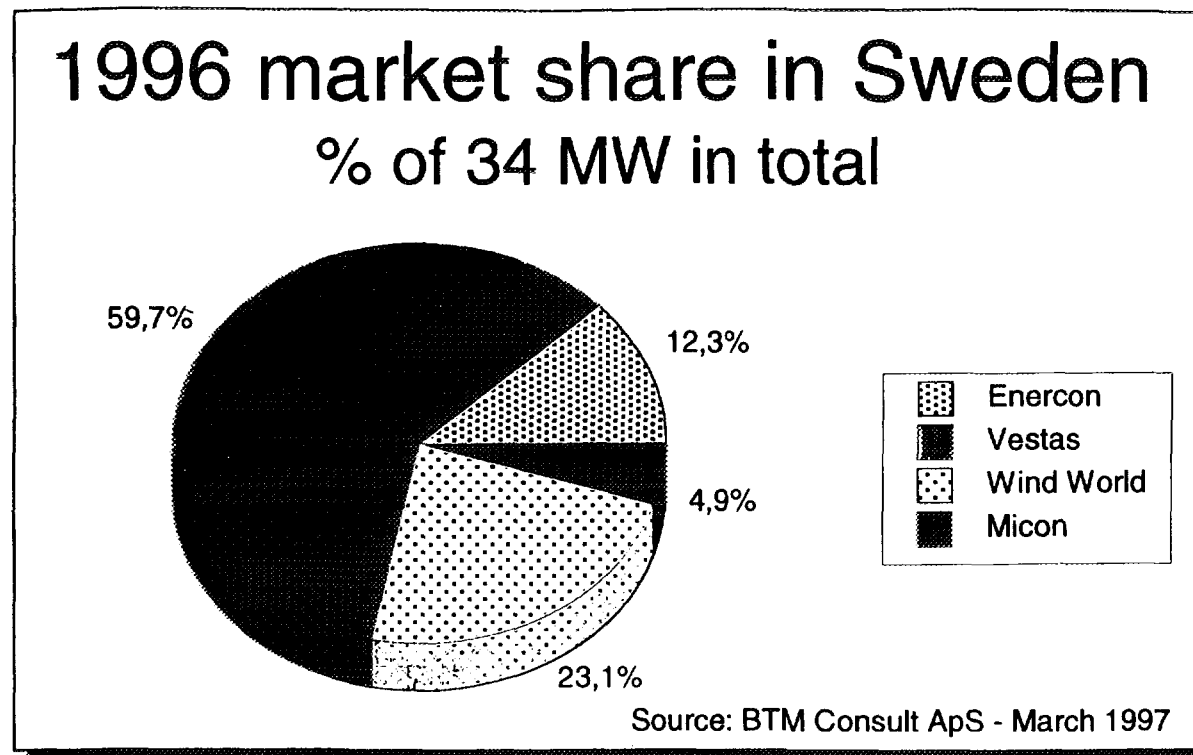


Figure AP-14: Manufacturers market share in the UK 1996

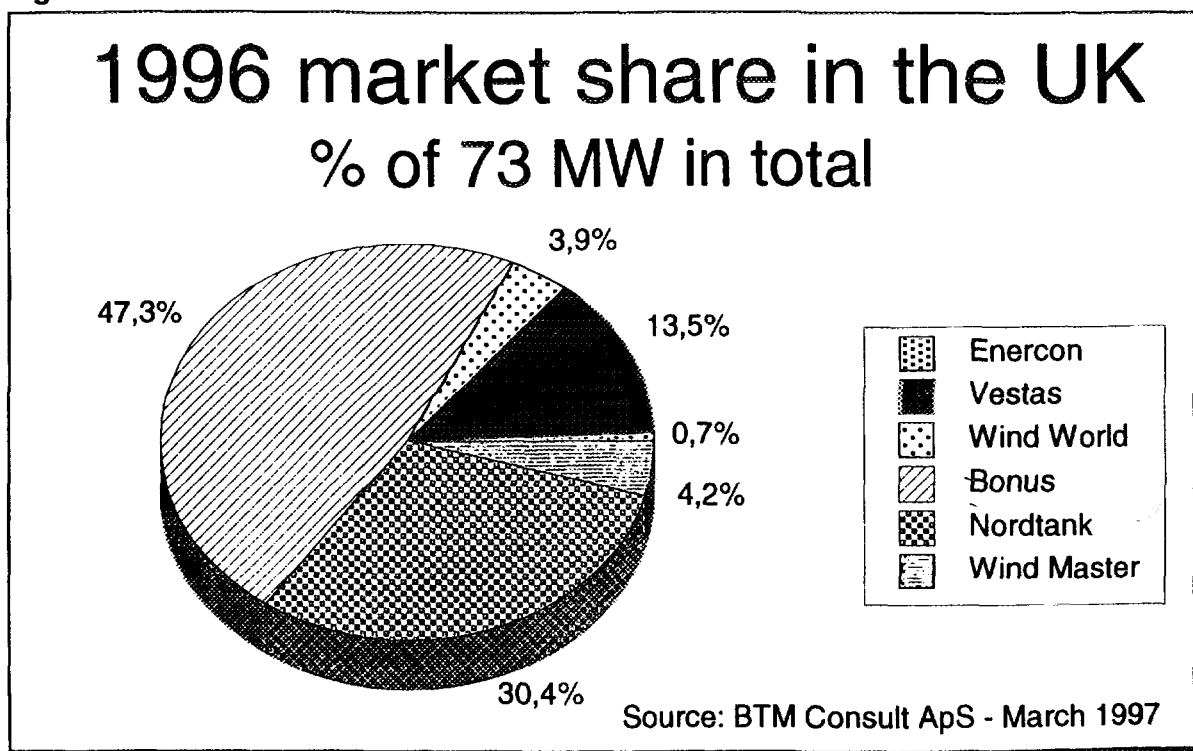


Figure AP-13: Manufacturers market share in Sweden 1996

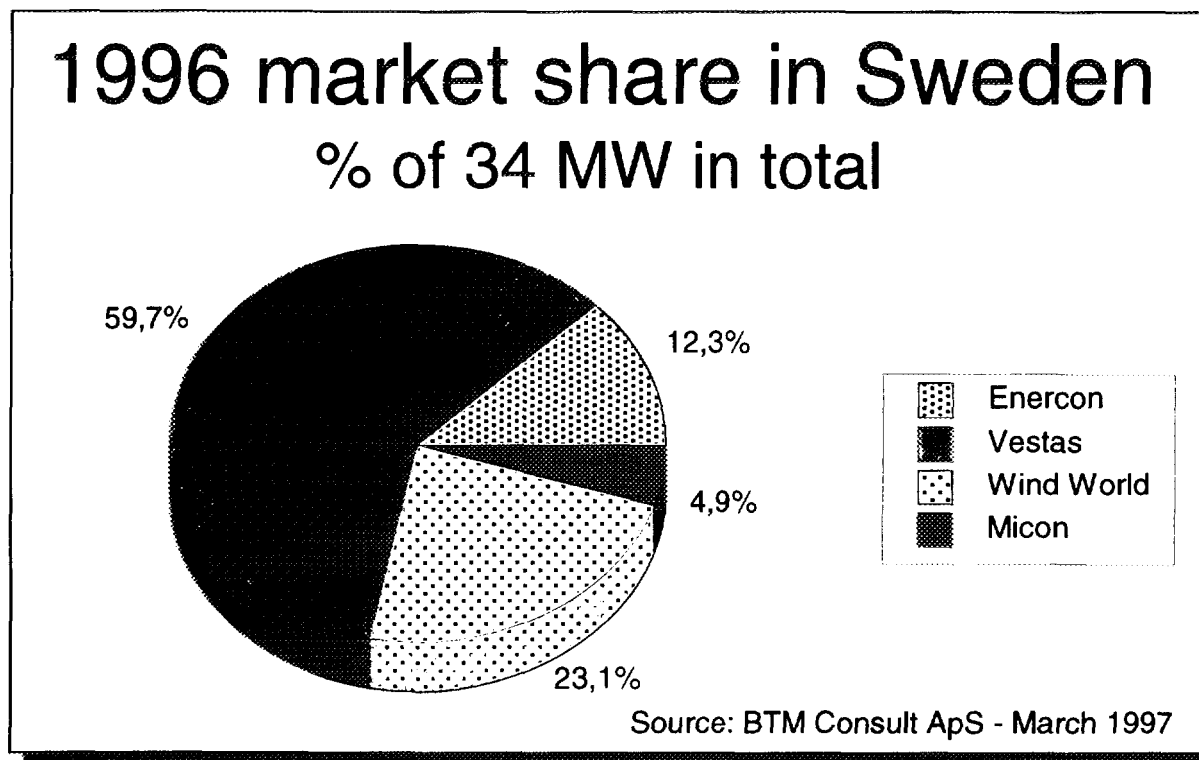


Figure AP-14: Manufacturers market share in the UK 1996

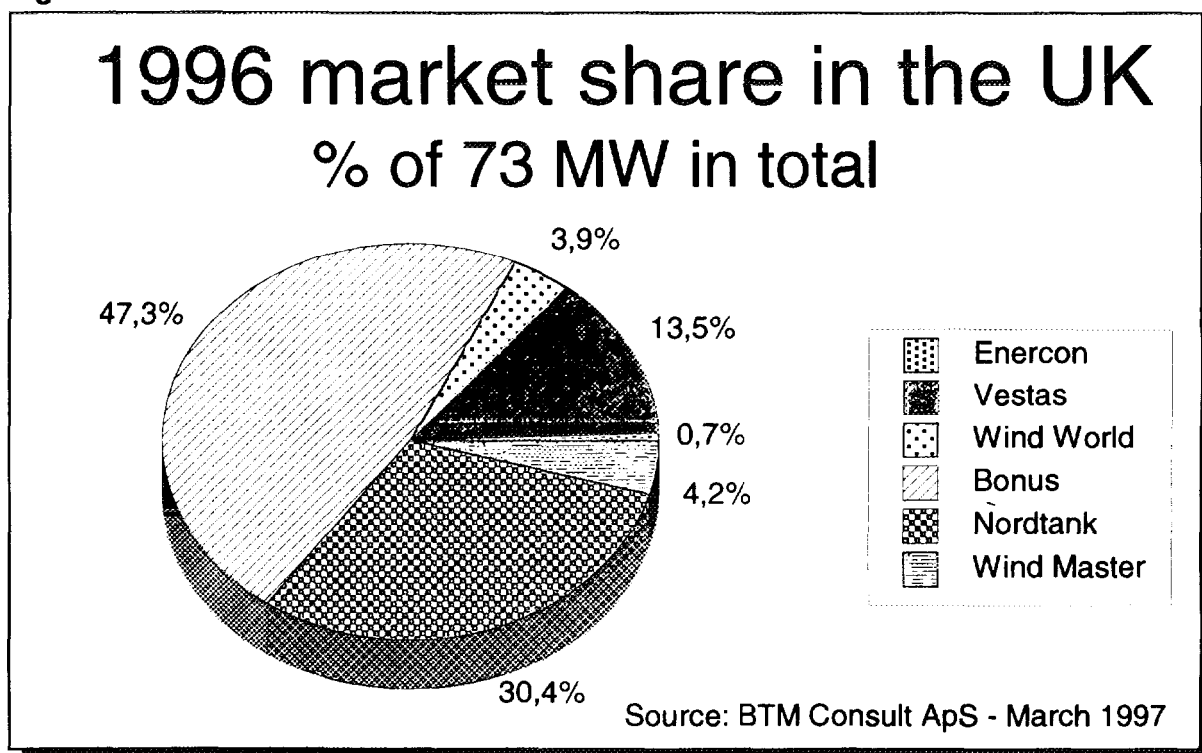


Figure AP-15: Manufacturers market share in China 1996

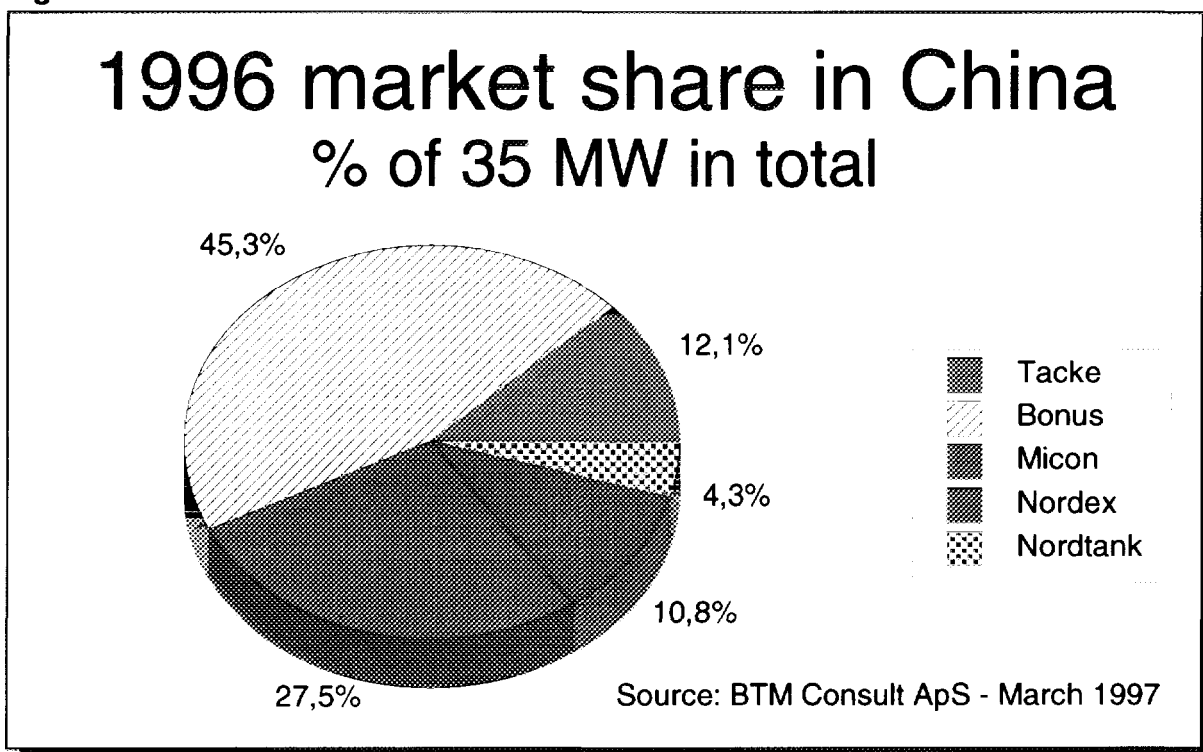
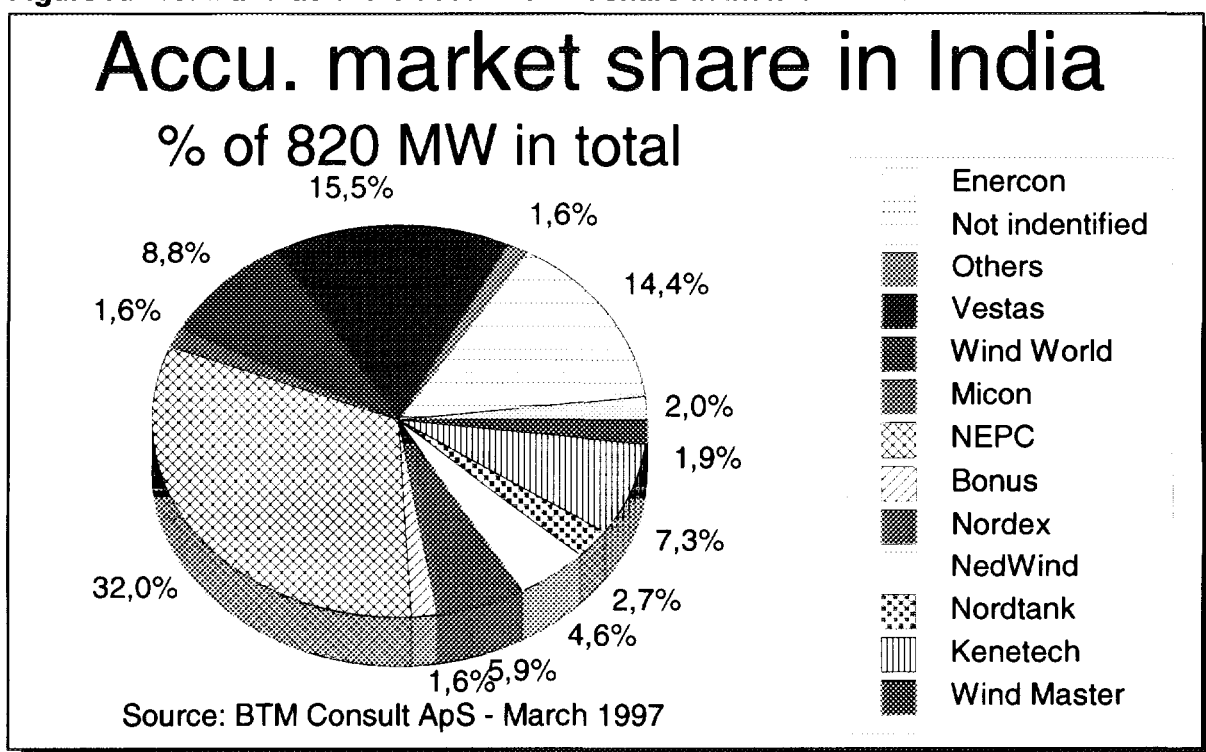


Figure AP-16: Manufacturers accu. market share in India until the end of 1996



F: Profile of wind turbine manufacturers

AMERICAN

FloWind Corporation is a **US** wind turbine manufacturer and developer and the only manufacturer in the world who has long time operational experience with vertical axis wind turbines. FloWind bought Advanced Wind Turbines (AWT) in 1994 and has since then installed a few AWT-26 wind turbines.

Kenetech Corporation has for many years been the largest **US** manufacturer of wind turbines. Kenetech Windpower filed for Chapter 11 in May of 1996 and will most likely never return as a wind turbine manufacturer again. Kenetech has had an important role in the industry for many years, especially due to the different market approach which Kenetech took as a fully integrated manufacturer and world wide developer.

Zond Systems Inc. is a **US** wind turbine manufacturer and developer, and today the leading company in America. Zond started to develop their own wind turbine in 1993 and the first prototype of the Z40 (550 kW) wind turbines was installed by 1994. The first prototype of the Z-46 (750 kW) was installed during the fall of 1996. Zond was bought by Enron Corporation in January of 1997 and is now a subsidiary of Enron Renewable Energy Corp.

EUROPE (Denmark - Germany - The Netherlands)

Bonus Energy is a **Danish** manufacturer who has developed and sold wind turbines for more than 15 years. Bonus is specialized in developing, sales and installations of wind turbines and has experience from more than 2000 installed units. Bonus' wind turbine program reaches from 150 kW to 1 MW and their design is based on a 3 bladed, constant speed, stall concept. The new 1 MW machine is a little different than previous models, thus it is equipped with active stall.

Micon A/S is a **Danish** manufacturer who has developed and sold wind turbines since 1983. Micon has experience from more than 2000 wind turbines. Micon manufactures their wind turbines in Denmark, India and the USA. Micon has a license agreement in India with NEPC. Micon's wind turbine program reaches from 225 kW to 1 MW and their design is based on a 3 bladed, constant speed, stall concept.

Nordex is a **Danish** manufacturer who has developed and sold wind turbines since 1987. Nordex has been very successful with their 1 MW model especially in Germany. Nordex' wind turbine program reaches from 225 kW to 1.2 MW and their design is based on a 3 bladed, integrated gearbox, constant speed, stall concept. Nordex was bought in 1996 by the German company Balke-Dürr GmbH which is part of the large Deutsche Babcock Group.

Nordtank Energy Group A/S is a **Danish** wind turbine manufacturer who has produced and sold wind turbines since the early 1980s. More than 2000 Nordtank wind turbines are producing electricity in 15 different countries today. Nordtank's wind turbine program reaches from 550 kW to 1.5 MW and their design is based on a 3 bladed, constant speed concept. Nordtank went public on the Danish stock exchange in 1995 as the first European wind turbine manufacturer.

Vestas Wind System A/S is a **Danish** wind turbine manufacturer and the largest in the world. Since the early 1980s Vestas have installed some 1,200 MW (5500 units) in more than 20 different countries. Vestas is manufacturing a large part of their machine by themselves which includes blade production (>12,000 blades have been produced). Vestas' wind turbine program reaches from 225 kW to 1.5 MW and all of these are pitch regulated. Vestas introduced a new system in 1995 called OptiSlip and OptiTip. This system is available on their 600 kW and 1.5 MW model. OptiSlip is a special feature developed by Vestas and works like something between constant and variable speed.

Wind World is a **Danish** manufacturer who has developed and sold wind turbines since 1987. Wind World has experience from more than 900 wind turbines. Wind World's wind turbine program reaches from 170 kW to 750 kW and their design is based on a 3 bladed, integrated gearbox, constant speed, stall concept. Wind World introduced their new Optimal Speed Control system in 1996 which is a semi variable speed system which is only active at low wind speeds. This system is now available on the most recent models.

Enercon GmbH is the largest **German** wind turbine manufacturer. Enercon was established in 1984 and has worked with energy converters and wind turbine development since then. Enercon introduced a new design concept to the market in 1992/93 which was a multipoled gearless wind turbine. By the end of 1996 some 300 MW of the E40/500 kW had been installed. Enercon are developing very high-tech machines with 3 blades, pitch and variable speed, which is combined with their own multipoled ring generator. They have especially been strong in Germany where they have had a market share of more than 30% between 1994-1996. During 1996 Enercon made a new alliance with the German utility PreussenElektra which is only for export purposes. Until today Enercon has only had very little experience outside Germany.

Tacke Windtechnik GmbH is the second largest **German** wind turbine manufacturer. Tacke started to develop wind turbines in 1984 but has more than one hundred years of experience with gearbox manufacturing. A separate wind turbine company (Tacke Windtechnik) was established in 1990. Tacke are manufacturing wind turbines in the size between 80 kW to 600 kW and installed a prototype of their newest 1.5 MW model in April of 1996. Tacke's design is based on a 3 bladed, integrated gearbox, constant speed, stall concept, although their latest 1.5 MW model is pitch regulated and operates at variable speed. Tacke has like Enercon only little experience outside Germany.

NedWind Rhenen BV is the largest **Dutch** wind turbine manufacturer. NedWind was established in 1990 as a merger between 3 different smaller companies who had all been involved in the wind industry since the early 1980s. NedWind is mainly active in Holland but have also installed wind turbines in the USA and India. NedWind's wind turbine program consists of both 2 and 3 bladed WTG's. They are mainly known by their 2 bladed N40/500kW and N54/1MW.

Windmaster is the 2nd largest wind turbine manufacturer in **The Netherlands**. Windmaster has been involved in the industry as a manufacturer since 1978 and has installed wind turbines in Belgium, Holland, India, UK and the USA. Windmaster's wind turbine program consists of both 2 and 3 bladed WTG's. They are mainly active with their 2 bladed 750 kW models today but a 3 bladed 300 kW model is also available from Windmaster. HMZ Windmaster went bankrupt in 1996, which resulted in the establishment of Dutch Windmaster (NL) and Turbowind (B) with equal rights to manufacturing of their WTG.

ASIA (India - Japan)

NEPC-Micon is an Indian/Danish joint venture mainly owned by the **Indian** company NEPC which is involved in many other activities. NEPC has only been active in India where they have been the leading manufacturer. All wind turbines from NEPC-Micon are based on technology transfer from Micon in Denmark.

Mitsubishi Heavy Industries is among many other things also a wind turbine manufacturer (**Japan**). They have mainly been active in California and England where they have installed 3 large projects. Mitsubishi Heavy Industries (MHI) is designing and manufacturing their WTG at their facilities in Nagasaki. MHI has mainly sold their wind turbines to SeaWest (US developer) and these projects have been financed by the Japanese company Tomen Corporation. MHI's main product has until today been a 250 kW but a 5-600 kW model is also available today.

Emerging manufacturers

The following list of wind turbine manufacturers represent companies who has in the last couple of years grown to a size which will include them as potential candidates for the future "Top-10" list of the largest manufacturers in the world.

Desarrollos Eólicos is a **Spanish** wind turbine manufacturer and 100% owned by Abengoa, a Spanish company engaging in almost any activity within the field of electricity and electronics. Abengoa first initiated a joint-venture with the then US Windpower (now Kenetech). This joint-venture was ended in 1992. Abengoa then moved on to start a new company called Desarrollos Eólicos. Since then, they have been working on an upgraded 300 kW model based on their AWP 100 turbine. Some 60 units of their new 300 kW WTG were installed during 1996. Desarrollos Eólicos has a strong financial partner in Abengoa.

Ecotécnia is a **Spanish** wind turbine manufacturer. They have a 225 kW wind turbine on the market and have just installed 2 units of their new 600 kW during 1996. This model is expected to be used in several larger projects during 1997. Ecotécnia started working with renewable energy in the late 1970s, primarily solar energy at the beginning. Ecotécnia has like other Spanish companies mainly sold their wind turbines in Spain, except for 10 units to India in 1995.

Gamesa Eólica is a **Spanish** joint-venture established and owned by Gamesa Group (51%), Vestas (40%), and Sodena (9%). Sodena is a branch of the local government. Gamesa Group is a large company with activities in most parts of the world. The company is owned by the electricity company Iberdrola (40%), a bank, BBV, (49%), and the founder owns the last 20%. Gamesa Group produces a variety of things, from parts for the aviation industry, gear boxes, electronics, products made from glass fibre and similar materials, and much more. The Gamesa Eólica joint-venture began at the end of 1993 and is today the largest manufacturer in Spain.

MADE is 100% owned by the "**Spanish** national" electricity company ENDESA. Today, MADE's largest model on the market is a 330 kW wind turbine, but they have been working on a 5-600 kW model of which the first were installed in 1996. The introduction of this prototype was delayed, but it is expected to be ready for production during 1997.

G: Abbreviations and technical units

Accu.	Accumulated = Cumulative
AWP	Abengoa Wind Power
AWT	Advanced Wind Turbines
CO ₂	Carbon Dioxide
const. speed	Constant Speed
DEWI	Deutsches Windenergie-Institut
EdF	Electricité de France
EU	European Union
FSU	Former Soviet Union
GNP	Gross National Product
IEA	International Energy Agency
INR	Indian Rupees (USD 1 = 35 INR - March 1997)
IPCC	Intergovernmental Panel on Climate Change
mill.	Million
MHI	Mitsubishi Heavy Industries
MNES	Ministry of Non-Conventional Energy Sources
OECD	Organization for Economic Co-operation and Development
pf	Pfennig (100 pf = 1 DEM)
PMG	Permanent Magnet Generator
PV	Photo Voltaics = Solar cells
var. speed	Variable Speed
WEC	World Energy Council
WTG	Wind Turbine Generator = Wind Turbine

Technical units:

kJ	kilo Joule = 1000 Joule
kW	kilo Watt = 1000 Watt
MW	Mega Watt = 1000 kW
kWh	kilo Watt hour = 1000 Wh = 3600 kJ = 0.086 kg of oil
MWh	Mega Watt hour = 1000 kWh

$$\text{Capacity Factor (CF)} = \frac{\text{Annual production (kWh)}}{\text{WTG name plate capacity (kW)} * 8760 \text{ hours}} * 100 (\%)$$

H: Comments and changes

This issue of the World Market Update 1996 is version #2. BTM Consult has received new and more updated information since version #1. Some of this information has been included in version #2 where it has been possible without any major changes.

Please note the following information.

Included in version #2

Page 3 & 12

The Nordtank off-shore wind farm installed in the Netherlands during 1996 consisted of 19 units and not 16. This brings the total capacity of the project to 11.4 MW.

Not included in version #2

Page 14-17 & 40-41 & 43

As part of the supply side assessment BTM Consult received a reference list from Nordtank which had not been completely updated for 1996. We have been informed about this and a new assessment has therefore been completed for Nordtank. This shows a total sale in 1996 equal to 110 MW instead of 82 MW stated in the previous version of the World Market Update 1996. Domestic sales has increased from 14 MW to 24 MW and export has increased from 68 MW to 86 MW (78.2% export). The export part consists of sales to China (6.55 MW), Germany (28.7 MW), India (9.35 MW), the Netherlands (19.7 MW), UK (21.6 MW), and others (0.3 MW). These new numbers increases Nordtank's market share for 1996 and effects market shares for other manufacturers. These changes has not been incorporated in this version of the World Market Update 1996. Nordtank's global market share in 1996 is according to the new data around 8.5% and their market share has increased in China, Denmark and Germany.

Please contact BTM Consult ApS (see next page) if you have any questions to these new amendments.

BTM Consult ApS company profile

BTM Consult ApS, BTM-C, is an independent consultancy company specialized in services regarding renewable energy. The staff at BTM-C has been working with wind energy utilization since 1979.

BTM-C was founded in 1986 with the aim of being a consultancy company of high reputation and a contributor of staff experience to exploitation of wind energy throughout the world. BTM Consult Corporation located in Palm Springs, California, USA, was established in 1988 as a fully owned subsidiary of BTM Consult ApS. Its primary task has been for nearly 8 years to manage, administrate and supervise service and maintenance of approx. 20 MW wind farm projects.

With almost two decades of experience with wind energy, BTM-C offers knowledge gained through hands on experience from ownership, participation and daily management of wind energy projects domestically and abroad. Services provided by BTM-C includes;

- Market assessment and business development,
- Feasibility studies and wind resource assessments,
- Wind farm management,
- Appraisals, due diligence investigations, financial analysis, technical evaluations of wind turbines, performance and reliability assessments of existing and planned wind energy projects, etc.

BTM-C has through years of international involvement established a technology base with contacts all over the world. This enables BTM-C to follow international policy development closely and to assist with market analysis, technology transfer and establishment of local joint ventures.

For more information, please contact our office or take a look at our internet web pages.



BTM Consult ApS

I.C. Christensens Allé 1

DK-6950 Ringkøbing

Denmark

Phone: +45 97 32 52 99, Fax: +45 97 32 55 93

E-mail: btmcwind@post4.tele.dk

Mr. Birger T. Madsen

Mr. Per Krogsgaard

Mr. Kell Øhlenschläger

Internet: <http://home4.inet.tele.dk/btmcwind/index.html>